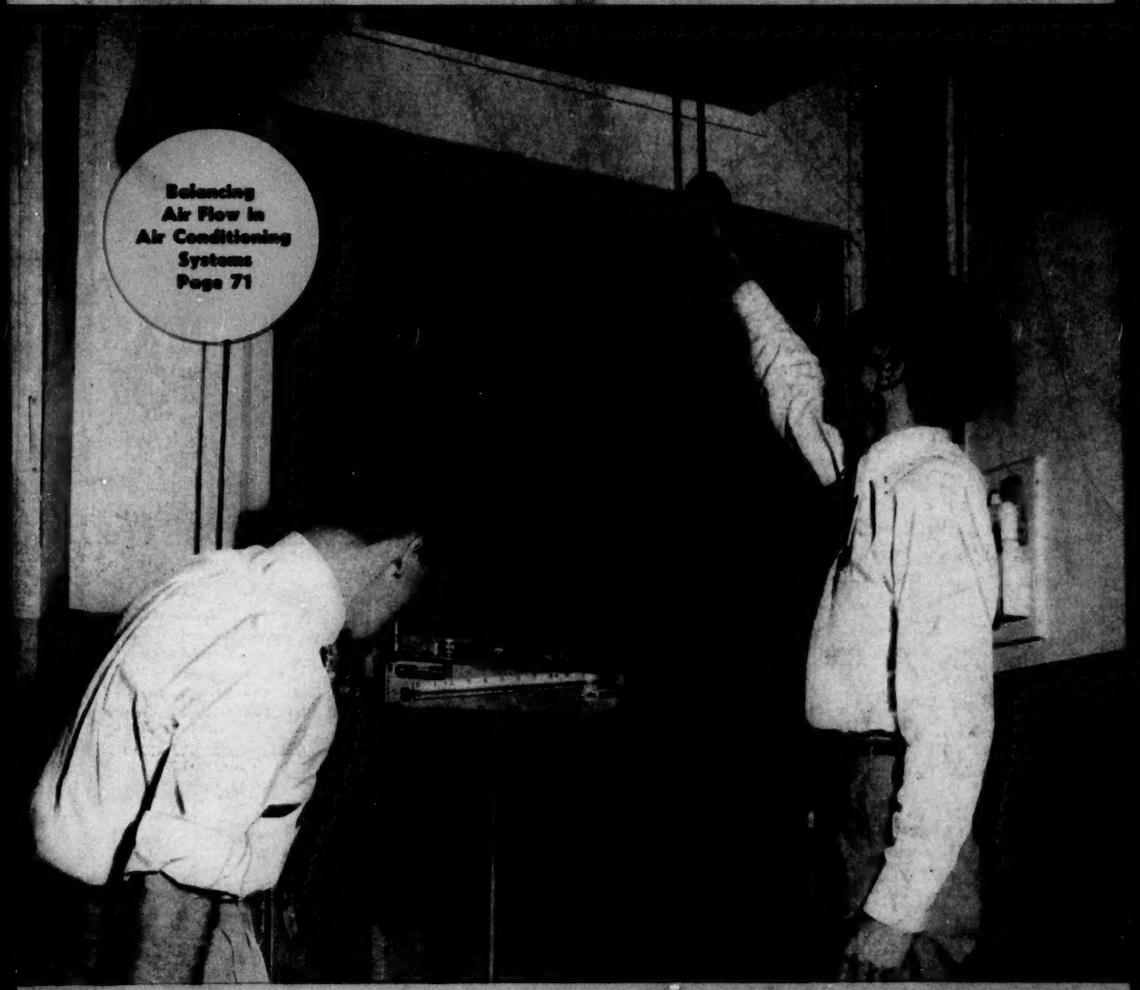
AUGUST, 1951

HEATING AND VENTILATING

INCLUDING AIR CONDITIONING — PIPING — REFRIGERATION — AIR SANITATION



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Steam Pipe Sizing Analysis . . page 85

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ARMSTRONG "BLAST" TRAPS SPEED UP HEATING

of Single Pipe Coils, On-and-Off Multiple Coils, Unit Heaters, etc.

IN equipment where large amounts of air accumulate when the steam is turned off, and where the air can be pushed out ahead of the steam, Armstrong "Blast" Traps provide remarkably fast heat-up. A corrosion resistant invar and stainless bi-metal strip holds open a very large vent which lets air whistle right through the trap when equipment or lines are cold. As soon as steam reaches the trap, the bi-metal closes the big vent.

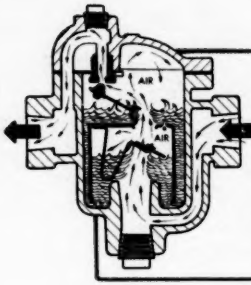
Armstrong Blast Traps combine the benefits of quick heat-up with the dependable service of mechanical traps. There is no bellows to leak or collapse due to high pressure. In fact, the traps are hydraulically tested at 500 lbs. pressure before they leave the factory.

Call your nearby Armstrong Representative for details and prices.

ARMSTRONG MACHINE WORKS

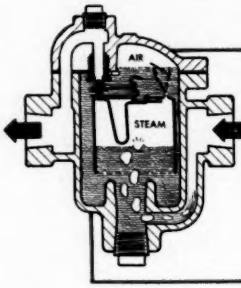
846 Maple Street • Three Rivers, Michigan

AIR WHISTLES RIGHT THROUGH



VENT OPEN

Note large air bubbles "whistling" through large thermic-control vent to be discharged with condensate through open trap valve. Shaded grey area is condensate.



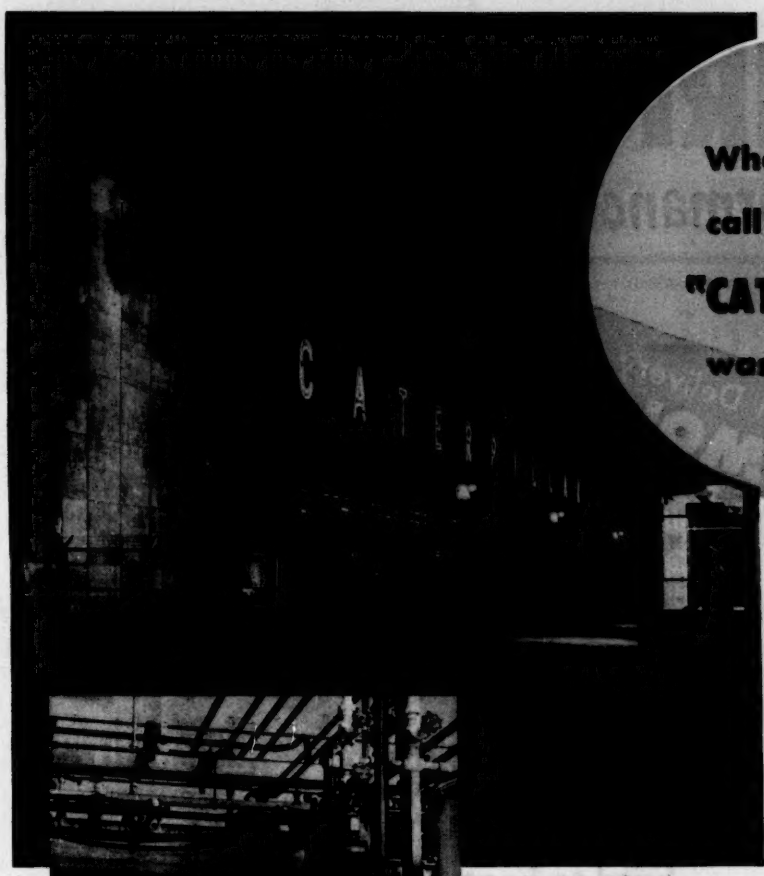
VENT CLOSED

After accumulated air and condensate are discharged, large vent closes. Small vent is always open to handle ordinary volume of air entering trap.

THE ARMSTRONG STEAM TRAP BOOK tells all about Armstrong Blast and Standard Traps—where to use them and how to select and install them. You are welcome to a copy. Just write for it.

SEE OUR CATALOG IN SWEET'S

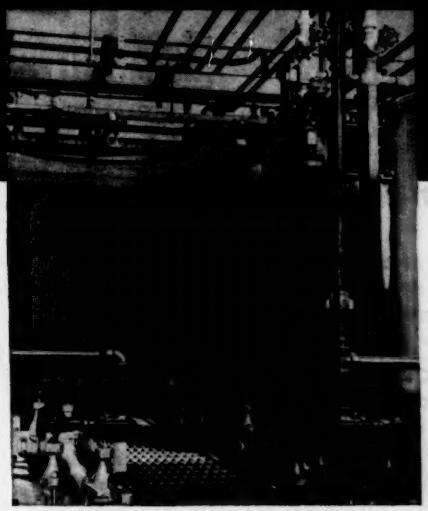
ARMSTRONG STEAM TRAPS



When the call came, "CATERPILLAR" was ready

Another of America's vital plants equipped for lasting efficiency with

JENKINS VALVES



Among the thousands of Jenkins Valves on plant pipelines are these, where the identifying "highway yellow" paint for "Caterpillar" machines is prepared. Over 300 valves are used for flow control in each of several paint mixing units.

They're working around the clock these days at Caterpillar Tractor Co., Peoria, Ill.—one of the largest producers of earth-moving equipment and diesel engines. The big yellow "Caterpillar" machines are urgently needed—both for Defense and for essential civilian construction.

Future-minded planning of this modern industrial plant helps keep production moving. All operating equipment, for example, was selected on the basis of performance and long service life. The engine factory (above), like every building of Caterpillar Tractor Co., is equipped with Jenkins Valves.

Today, Jenkins is bending every effort to meet the Nation's need for valves. It's a big order. The men responsible for the defense production program know that valves are vital to plants readying the country for any emergency. And leading architects, engineers, and contractors rely on Jenkins for peak operating efficiency and economy.

For they know Jenkins builds *extra* endurance into valves—proved by low upkeep cost records in every type of service. Yet, despite this extra value, *you pay no more* for Jenkins Valves. For new installations, for all replacements, let the Jenkins Diamond be *your* guide to lasting valve economy. Jenkins Bros., 100 Park Ave., New York 17; Jenkins Bros., Ltd., Montreal.

JENKINS VALVES

LOOK FOR THE DIAMOND MARK

TRADE JENKINS MARK

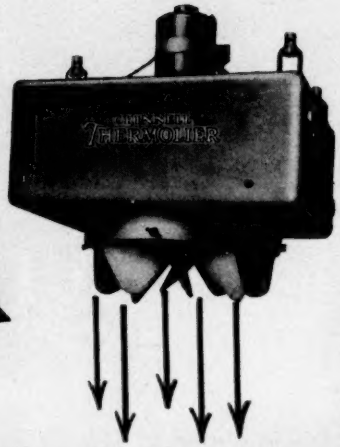
Jenkins Bros.

Sold through leading Industrial Distributors everywhere.

DOWNRIGHT

better performance

Vertical Delivery
THERMOLIER
Unit Heaters . . .



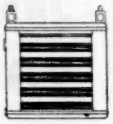
RIGHT DOWN

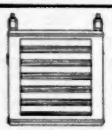
where maximum heat is desired...

in warehouses, plants and other hard-to-heat buildings

4 MODELS . . . . . 18 SIZES

Vertical Delivery


Horizontal Delivery


Textile Model

Velocity Nozzle

A thermostatic trap, the simplest and least expensive of all traps, is practical because of Thermolier's exclusive cooling leg.

Maximum capacity assured, annoying destructive water hammer eliminated — by built-in pitch of tubes and internal cooling leg which assure continuous drainage of condensate.

Damaging strains caused by expansion and contraction eliminated by "U" type expansion tubes.

Safety and durability assured with leak-proof tube-to-header construction.

Five other important construction features. Write for Thermolier Catalog.

HEATING COMFORT AND ECONOMY. Heat is forced down to the working level . . . not banked uselessly at the ceiling level. Thermoliers provide quick heating from a cold start. Desired room temperatures are easily maintained within a close range.

ADAPTABILITY TO EQUIPMENT AND FLOOR LAYOUT. The units and the simple piping are overhead where they do not interfere with arrangement of operating machinery or equipment and do not take up valuable floor or wall space. Units are easily relocated at any time to meet changes in plant layout or heating requirements.

LOW FIRST COST. Thermoliers are so efficient and so compact that their heating capacity is often equivalent to the capacity of cast iron radiation or pipe coils of twice the cost.

GRINNELL

WHENEVER PIPING IS INVOLVED

Grinnell Company Inc., Providence 1, Rhode Island • Sales Offices and Warehouses in Principal Cities

pipe and tube fittings • welding fittings • engineered pipe hangers and supports • Thermolier unit heaters • valves Grinnell-Saunders diaphragm valves • pipe • prefabricated piping • plumbing and heating specialties • water works supplies industrial supplies • Grinnell automatic sprinkler fire protection systems • Amco humidification and cooling systems

HEATING AND VENTILATING

A MONTHLY MAGAZINE FOR ENGINEERS AND CONTRACTORS CONCERNED WITH THE DESIGN AND APPLICATION OF AIR CONDITIONING, REFRIGERATION, PIPING, AIR SANITATION, HEATING AND VENTILATION IN BUILDINGS

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The Contents of HEATING AND VENTILATING are indexed monthly by Industrial Arts Index and by Engineering Index

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Also Publishers of
HEATING & PLUMBING EQUIPMENT NEWS
and technical books.

THIS MONTH'S COVER

S. H. Chandler, left, and M. H. Berry, Jr., right, sales engineers of York Corp., are taking air velocity measurements using pitot tubes, as part of a step in balancing air duct flow. For details of steps to follow in balancing such systems, see page 71.

Not One But Five

Trane Model P Unit Heater
Projects Heat Down to Floor
Trane Model H Unit Heater
Horizontal Propeller Type
Trane Corridor Unit Heater
High Velocity Blower Type Unit
Trane Gas Unit Heater
Built Like a Boiler
Trane Force Flo Heater
DeLuxe Cabinet Type Unit
TWO GREAT DIFFUSERS
Trane Louver Fin Diffuser
Better Diffusion with the Model H
Trane Louver Cone Diffuser
Greater Throw from the Model P

MANUFACTURING ENGINEERS OF VENTILATING,

Great Unit Heaters

Another Example of the Completeness of the Trane Heating Line

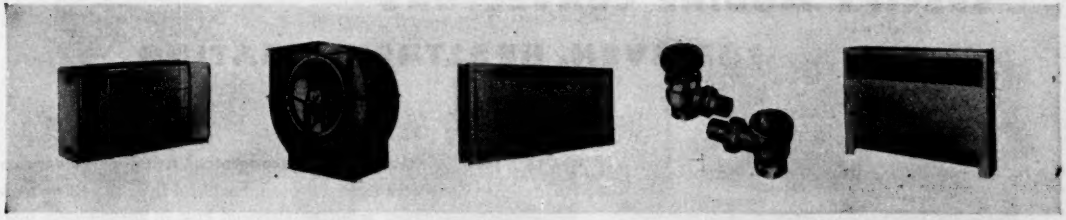
Not one, not two, but five great Trane Unit Heaters to solve your heating problems exactly. Whether you need a unit for steam, hot water or gas; whether you want vertical discharge or horizontal throw; whether you want to blanket doorways or heat entries – no matter what the unit heater application, there is a Trane product that will fit the project perfectly. Only Trane offers such a complete unit heater line.

Unit Heater Diffusers. Not only is the line complete but it is jam-packed with exclusive Trane features. Outstanding examples are the Trane Louver Cone and Louver Fin Diffusers. With them you put heat exactly where you want it. You can get greater distance of throw. You can change adjustments easily and quickly when job requirements change. You can split the air stream into segments making it possible for one unit to do the work of two. With this greatly increased unit flexibility, you get greater value for your heating dollar.

The Trane Coil. Still another feature is the Trane Coil – the heart of all steam and hot water units. This is the coil that gives you the solderless mechanical bond for greater heat transfer, the rolled and bushed header joint for leakproof operation, the six-step fin construction for greater sturdiness.

Exclusive features plus five units from which to choose – that's why you'll find the best answer to your unit heater problem in the Trane line.

A Complete Heating Line. You'll also find the right answer to hundreds of other problems in Trane's complete line of heating, ventilating, heat exchange and air conditioning products. Like Trane Unit Heaters, each product offers a wide range of types and sizes from which to select. All are studded with exclusive Trane features. And when you incorporate them into complete systems, you get the added advantages of using products that are designed, tested and built together for service together. Whatever your heating, air conditioning or air handling problem, look for the answer in the complete Trane line.



Trane Unit Ventilators—for better schoolroom ventilation

Trane Centrifugal Fans—a complete line with wheels diameter to 109"

Trane Heating Coils—ideal for the central heating system

Trane Steam Specialties—a complete array of traps and valves

Trane Convectors—the room heater that tucks away under the window

THE TRANE COMPANY, LA CROSSE, WISCONSIN

Eastern Mfg. Division, Scranton, Pennsylvania

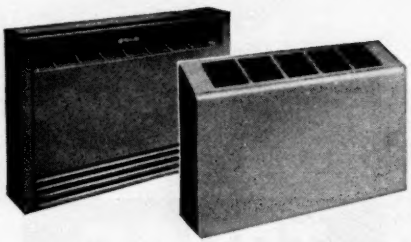
Trane Company of Canada, Ltd. . . . Toronto

OFFICES IN 80 U.S. AND 14 CANADIAN CITIES

TRANE

HEATING AND AIR CONDITIONING EQUIPMENT

SPECIFY MODINE CONVECTORS FOR EVEN, HEALTHFUL HEATING



Choose from two enclosure types. Type F for either recessed or free-standing installation. Type S designed for wall placement.

Modines give many years of economical, trouble-free service

Modine Convectors maintain even, healthful floor-to-ceiling temperatures — *in any weather*. Original cost is surprisingly low, and Modines require a minimum of servicing. They are ruggedly constructed to withstand schoolroom hazards — can't burn hands or clothing.

Modines can be supplied with standard heating units for hot water or 2-pipe steam — or with the new Quiet-Seal heating unit for 1-pipe steam.

Modine

CONVECTORS

For the full story, call your Modine representative listed in the classified section of your phone book. Or write direct. Modine Mfg. Co., 1511 DeKoven Ave., Racine, Wis.

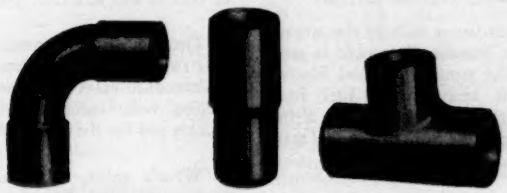
R-1104

look! ...it must be a *Streamline*® fitting!

Streamline® solder type fittings are really made to last . . . and they'll make a neater, quicker installation

If Cleopatra's plumber had used STREAMLINE fittings we wouldn't be surprised if they would still be in pretty serviceable condition today. For STREAMLINE solder type fittings are really made to last. They cannot rust, they're not loosened by vibration and they're virtually free from clogging. STREAMLINE fittings assure a snug-fitting, tightly joined system that tests leak-proof on the first try and doesn't develop leaks later. When you install STREAMLINE fittings, you can be sure you're installing a permanently reliable conducting system whether for plumbing, heating, air conditioning or industrial use.

And here's something else . . . because of their design, precision manufacture and accurate dimensions, STREAMLINE solder type fittings can be installed quickly and the uniform depth of the solder joints makes it easy to compute the exact length of tubing needed. Thus STREAMLINE fittings not only assure a permanent installation, they also reduce job cost and increase the number of installations a contractor can handle.



STREAMLINE wrought and cast fittings are available in a complete range of standard sizes.

See your jobber for further information or write for catalogs S-351 and W-251 describing our complete line of STREAMLINE wrought copper and cast bronze fittings.

63

MUELLER BRASS CO. STREAMLINE PRODUCTS

MUELLER BRASS CO. PORT HURON 2, MICHIGAN

"We've Cleaned Out The Trouble Spots in Bunker Oil Transport Layouts!"

HOW IT WORKS

Fuel from underground storage (A) flows through pipelines (B) heated by safe 28-volt current from Transforming Energizer (C). No caking — heat spreads evenly over entire system. Thermostat (D) controls temperature at 120°F., makes system 100% automatic.

During intermittent shutdowns, fuel temperature is maintained automatically. During seasonal shutdown, fuel can solidify — Thermal Electric will melt out the pipe system.

"We've found the simplest way to eliminate the hazards and trouble-spots in steam pipe heating layouts — just eliminate the steam entirely! Now we engineer maintenance-free bunker oil transport with Thermal Electric.

"Steam or water coils in the storage tank? That bundle of trouble is gone forever! The simple Thermal Electric Tank Unit removes the fuel from *unheated* storage. Stratification is impossible since the bulk of the fuel stays solid until melted for use.

"What about the snarl of pipes and valves of recirculation? Thermal Electric has scrapped all that too, as the pipes are heated by passing low-voltage electricity through them—independent of boilers and burners.

"Getting rid of this excess baggage gets rid of the excess costs, too. With maintenance costs eliminated and operation fully automatic, the savings quickly pay for the original investment.

"What's more, Thermal Electric's positive *guarantee* lifts the responsibility for perfect performance from the engineer's shoulders. From our experience, we'd say that the best way to clean out the trouble spots from your oil burner layouts is to specify Thermal Electric *Standard* Systems!"

PAT. NO. 2,224,403 HVS-2

Thermal Electric Fluid Systems INC.

Fluid Systems Inc., 1881 Dixwell Ave., New Haven 14, Conn.

Please send me "The Common Sense of Heavy Fuel Transport" plus Customer List of hundreds of satisfied users.

*Name*_____ *Position*_____

*Firm*_____

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Thermal Electric and Fluid Systems, Inc. are trade marks registered in U.S. Patent Office

"Tough Fluids Flow Easily For Us with Thermal Electric Pipe Transport!"

"Our first step in engineering industrial fluid transport layouts is to specify Thermal Electric. This method of passing electricity through the same pipe that carries the fluid meets any requirements.

"Temperature is no problem. Thermal Electric will safely move fluids varying from luke-warm chocolate to liquid asphalt at 450°F. Precise automatic controls hold it within 2°F. of the design temperature.

"By using systems in tandem, we cover any distance. This zone-control also nails down the problem of different ambient temperatures. Fluids flow from cold outdoors to warm indoors with no temperature change.

"We design single discharge lines with no return loops and effect tremendous savings in critical materials and capital investment. With all-electric operation cutting maintenance practically to zero, the savings often pay for the original investment in less than a year!

"If pipe transport of heated fluids is among your projects, it would pay you to get the whole story of Thermal Electric Industrial Systems."

Fluid Systems, Inc. are specialty engineers in the handling of industrial viscous fluids. We are available as special aides to consulting or staff engineers in designing transport systems for any fluid.

YEARS OF PERFORMANCE

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Asphalt: 182' at 450°F.

Duff Baking Mix Division
American Home Foods, Inc.
Molasses: 970' at 140°F.

Congoleum-Nairn, Inc.
Emulsion Paint: 337' at 100°F.

General Mills, Inc.
Corn Syrup: 223' at 110°F.

Individual Drinking Cup Co.
Paraffin: 1,489' at 170°F.

Monsanto Chemical Company
Water: 742' at 70°F.

PAT. NO. 2,224,403 HVI-2

Thermal Electric

Fluid Systems INC.

Fluid Systems Inc., 1881 Dixwell Ave., New Haven 14, Conn.

Please send me "Simplified Industrial Fluid Transport Cuts Costs" plus customer list.

*Name*_____ *Position*_____

*Firm*_____

*Address*_____

*City*_____ *State*_____

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16 gauge filter and holding frames assure well-aligned, rigid filter banks. Interlocking holding frames are easy to install and the rugged construction prevents distortion. Felt liners effectively prevent air by-pass.

Reinforcing rods drilled through the media insure rigidity and add to service life.

Herringbone-crimp media design assures dependable higher performance, larger dirt holding capacity, lower pressure loss, easier cleanability, reduced maintenance costs. Media is packed firmly and evenly in the frame resulting in even density throughout the filter and assuring uniform high efficiency over the entire filter area.

Here's why...

FAR-AIR* FILTERS

are unequalled in Quality, Construction and Performance

You can be sure of a high performance air cleaning job when you specify Far-Air Filters. Precision engineering plus quality construction to rigid specifications assure *uniform* performance. Available in a wide range of types and sizes for dirt, lint, grease, entrained water, paint, ink, and many other air filtering applications. Contact your local representative or write direct to Farr Company, P.O. Box 10187, Airport Station, Los Angeles 45, California.

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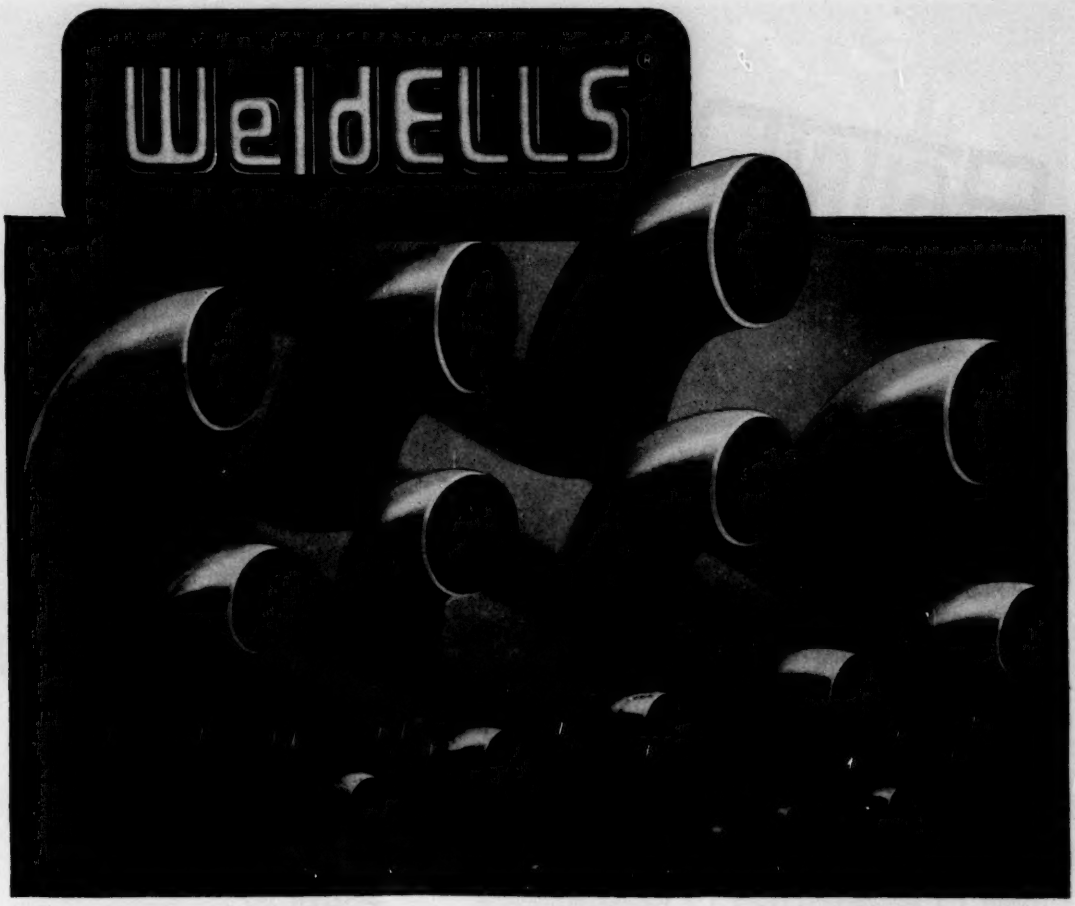
Los Angeles • Chicago • New York

Mfd under license by Control Equipment Co. Ltd. Montreal Canada



Just a Corner of the World's Largest Line

Illustrated above are the stock sizes of long-radius WeldELLS in a single weight and material. Multiply this group by all the weights, all the types and all the materials, and you have the world's largest line of forged fittings for pipe welding.

The Taylor Forge line grew to this size because nothing less could meet the demand for fittings of Taylor Forge design, quality, accuracy, uniformity.

Make this your final reason for insisting on the WeldELL line for every fitting and flange requirement. Coupon brings new data sheet described below.

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TAYLOR FORGE & PIPE WORKS • General Offices and Works: P. O. Box 485, Chicago 90, Ill.
Offices *in all principal cities* • Plants at: Carnegie, Pa.; Fontana, Calif.; Hamilton, Ont. Canada

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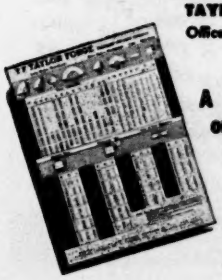

A volume of data on a single sheet

Data on welding fittings and flanges condensed on two sides of a durable, varnished, letter-size card. Particularly useful for the pipe designer. Coupon brings your copy.

Send one of your fitting and flange sheets to: 511-0851

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POSITION_____

COMPANY_____

STREET ADDRESS_____

CITY_____ ZONE____ STATE_____

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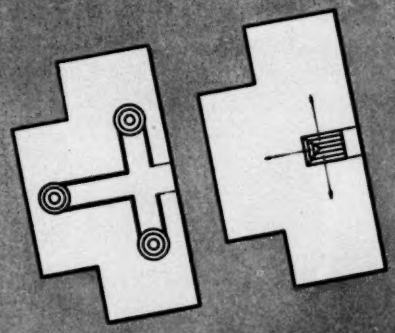
AGITAIR®

SQUARE & RECTANGULAR AIR DIFFUSERS

Save Metal... Cut Costs...

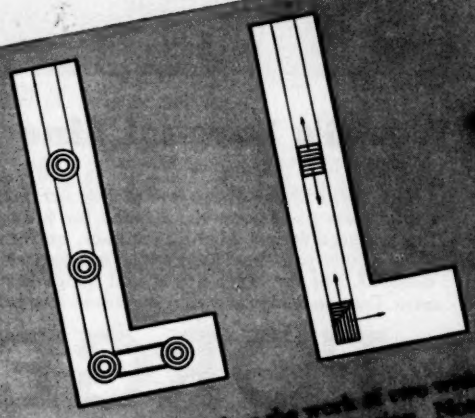
Without Cutting Efficiency

SHORTER DUCT RUNS



Substantial savings in metal and labor are yours due to the shorter duct runs with Agitair tailor-made diffusers.

FEWER OUTLETS



One diffuser does the work of two with no sacrifice in air distribution. Note the savings.

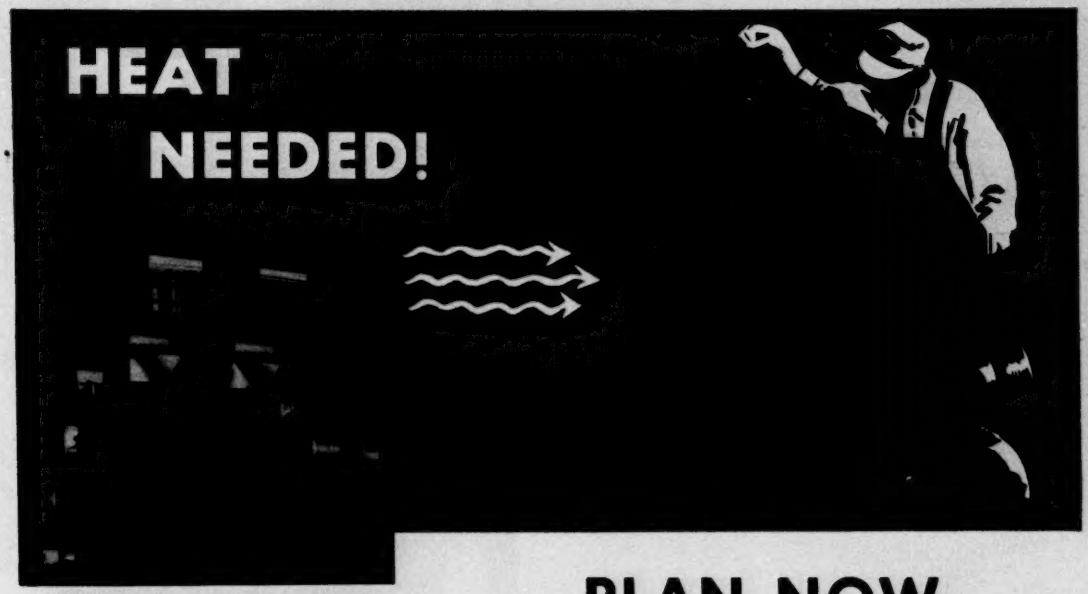
Now you can conserve critical materials and cut costs without cutting efficiency. How? By specifying AGITAIR Type R. Here's the only diffuser that may be assembled in a variety of patterns to provide blows in one-two-three and four directions with discharge orifices proportional to the area being served. Result: 100% air distribution in any shape area, from any location. What savings in metal and money! Get the facts and see for yourself.

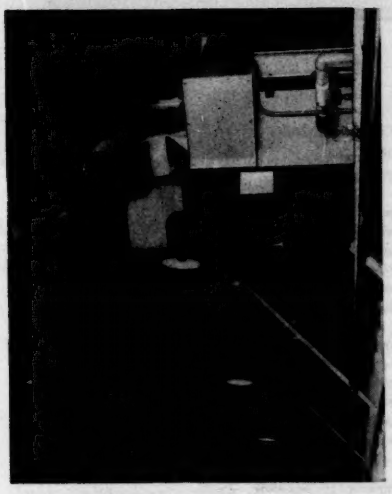
Write for Complete Data

AIR DEVICES Inc.

17 East 42nd Street New York 17, N. Y.

Air Diffusers • Air Filters • Exhausters





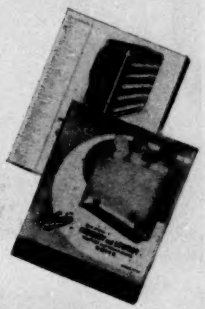
Suspended—Out of the Way!

"Buffalo" LOWBOY heaters take no floor space. Unit has efficient "Buffalo" fan for positive heat throw, and can be used for straight ventilation in warm weather. LOWBOY heaters are also used to supply make-up air in plants, mills and foundries where exhausters are used extensively.

PLAN NOW FOR NEXT WINTER

Quality-Built Heating, Ventilating and Fresh Air Units — A Right Model For Every Type of Installation

Getting the heat to the worker, or to the working area can sometimes be a problem—but not with the complete range of models in the "BUFFALO" Unit Heater line. This line includes everything from the efficient BREEZO-FIN heaters which can throw heat down over a section of benches or machines—to the big HIGHBOY and LOWBOY heating and ventilating units for distributing heat over large areas. LOWBOYS can be mounted on walls or ceilings, without using up productive or storage space. The narrow HIGHBOYS are economically installed on floors next to walls, where they require little space. *For complete information write for free Bulletin 3137-D and 3704-A.*



"Buffalo" FIRST FOR FANS

BUFFALO FORGE COMPANY

480 BROADWAY BUFFALO, NEW YORK

Canadian Blower & Forge Co., Ltd., Kitchener, Ont. Branch offices in all Principal Cities

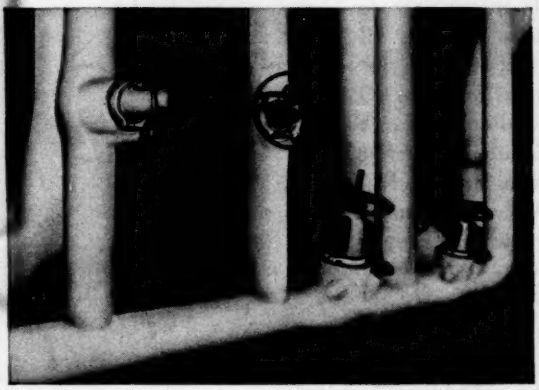
VENTILATING FORCED DRAFT | AIR WASHING COOLING | AIR TEMPERING HEATING | INDUCED DRAFT EXHAUSTING PRESSURE BLOWING

a better gate valve for 600-pound services ...CRANE pressure-seal bonnet design

Better—because these Crane valves completely eliminate bonnet joint maintenance. And because they assure power plants—industrial and utility—ideal flow conditions, with many added cost-reducing advantages.

For instance, they save on erection and suspension costs, because, size for size, Crane Pressure-Seal Bonnet Gates are much lighter in weight and more compact than flanged bonnet steel valves. Insulating Pressure-Seal valves takes less time and materials because of streamline contouring.

For complete information about Crane 600-Pound Pressure-Seal Bonnet Gates—also companion lines of 900 and 1500-Pound Gates, Globes, Angles, and Stop-Checks—send for Circular Ad-1819, or ask your Crane Representative for a copy.



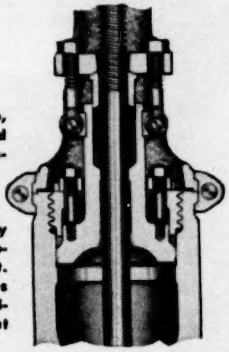
Boiler feedwater header in central station. No danger of bonnet-joint leakage; valves are Crane Pressure-Seal Bonnet Gates.

Patented and Patents Pending

600-Pound Butt Welding Gate for temperatures up to 1000° F. max.

NO BONNET-JOINT LEAKAGE OR MAINTENANCE

Bonnet joint is inside the valve, sealed with a wedge-shaped seal ring. Internal fluid pressure, acting upon the entire underside of bonnet, forces bonnet against seal ring and wedges it between the body and bonnet to form a pressure-tight metal-to-metal joint. Since pressure tightness does not depend on bolting, no periodic restressing of bonnet joint is needed.



FOR HIGH-PRESSURE HIGH-TEMPERATURE SERVICES

Crane Pressure-Seal Bonnet Gate valves are also available in 900 and 1500-Pound pressure classes.

CRANE CO.

General Offices:
836 S. Michigan Ave., Chicago 5, Ill.
Branches and Wholesalers Serving All Industrial Areas

VALVES • FITTINGS • PIPE • PLUMBING • HEATING

G. E. Cuts Cooling Costs For 8 Sheraton Hotels

NEW YORK'S PARK SHERATON

G-E Systems also in—

Detroit...Sheraton • St. Louis...Sheraton • Philadelphia...Penn Sheraton • Pittsburgh...Sheraton • Rochester...Sheraton • Springfield...Sheraton • Providence...Sheraton Biltmore

Famous chain gets year-round comfort with G-E Personal Weather Control—for 200 rooms or 20

For a whole hotel—or selected suites only—you'll get the low-cost, reliable air conditioning you're after with G-E Personal Weather Control.

G. E.'s attractive units fit all decors, say Sheraton officials. They're simple to install without extensive building alterations. Maintenance is negligible.

Ventilation costs are low—existing buildings like the Sheratons often need no provision for additional ventilation.

Guests enjoy coming back to rooms where they can dial their own "personal weather." Yet they don't disturb others. Handsome G-E units are whisper-quiet. Chilled water for cooling and hot water for heating are supplied from a remote central plant.

Write now for free data on G-E Systems for hotels, apartments, office buildings, or see your architect, engineer, contractor. General Electric Company, Air Conditioning Division, Sec. HV-20, Bloomfield, N. J.

SEE OUR CATALOG IN SWEET'S

You can put your confidence in—

GENERAL ELECTRIC

STAYNEW
PANEL FILTERS

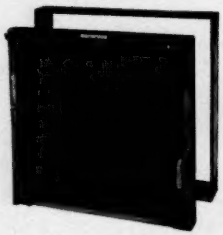
Dry-Type • Viscous-Type

designed for a broad range of prices and applications

Simple, efficient designs and rugged construction are featured. Most types provide for cell and frame assemblies, with heavy, serviceable handles and powerful cam-type locking latches. 18-gauge steel is used throughout. Supporting frames are so designed and drilled that they can be riveted together to form a flat bank. By the addition of angles, a series of "V's" can be formed. All models typify the high efficiency and low maintenance cost for which Staynew Filters have been famous since 1920.

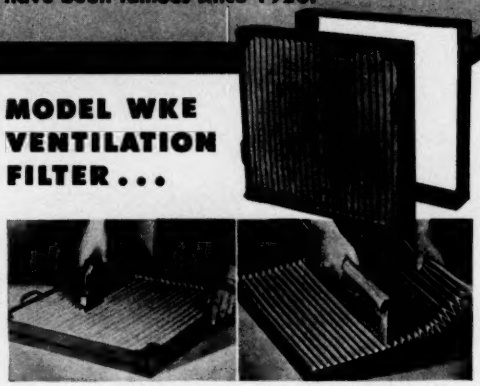
MODEL PVG VENTILATION FILTER . . .

• A low-cost, permanent, washable type filter. Designed for maximum use of medium with minimum of weight. Exclusive Staynew "RL" steel medium causes rapid changes in air direction and holds heavier particles. Finer particles are held by corrugated screen cloth and, as a final stage, layers of fine woven copper mesh. 2" and 4" units available.



Cross Section of Medium

MODEL WKE VENTILATION FILTER . . .



Easy to clean by vacuum

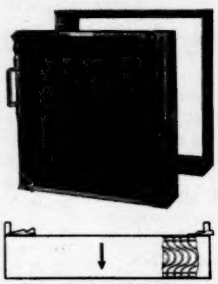
Filtering medium replaceable at low cost

Staynew Vacuum Cleaning Nozzle

Especially designed for heavy duty industrial applications. "V" construction provides large filtering area in small space. Wide variety of media available. Cleaning simple and easy with Staynew Saddle-type Vacuum Cleaning Nozzle. 2" and 4" deep units available. Fire Underwriters Class I Approved when used with B-G Medium.

MODEL SPB SPRAY BOOTH FILTER . . .

DRY OR VISCOUS DEPENDING ON KIND OF PAINT USED. Removes paint spray particles from the ventilation air stream by means of a series of scientifically designed baffles. These baffles cause rapid changes in direction of air-flow and consequent impingement of particles, which collect and drain to the bottom of the unit.



Cross Section of Medium

NEW! MODEL PVR KITCHEN RANGE FILTER

Solves the problem of grease collection in exhaust hoods over ranges, steam tables or cookers. Eliminates fire hazard and odorous, unsanitary conditions. Exclusive Staynew "RL" steel filtering medium. Available in 3" deep units. *Lowest cost high grade range filter.*

Panels easily removed for cleaning in hot, soapy water. Automatic dishwashing machine ideal for this purpose.

Representatives in Principal Cities

★

Write for Complete Data, Mentioning Special Interests

DOLLINGER CORPORATION, 15 Centre Pk., Rochester 3, N. Y.

DOLLINGER PROTECTOMOTOR STAYNEW FILTERS

Remember the trade marks "tt" and "TUBE-TURN" are applicable only to products of TUBE TURNS, INC.

Make piping permanent and leakproof

PIPING PERMANENCE is always important but now, more than ever, any installation of piping should be leakproof, maintenance-free and have extra long life. A piping system, big or small, is only as strong as its weakest component. That's why welding fittings, for example, should be specified with care.

TUBE-TURN Welding Tees are drawn from seamless tubing to a barrel shape—the shape every tee wants to assume under pressure. This feature, together with the generous crotch radius and thickness, explains why TUBE-TURN Welding Tees withstand more pressure without yielding. Bursting pressures obtained in tests of representative fittings have averaged more than 25% higher than required by standard codes. Here's extra quality at no extra cost.

Get in touch with your nearby TUBE TURNS' Distributor. You'll find one in every principal city.

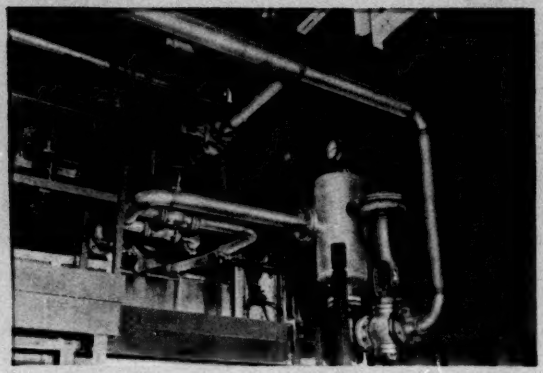
Write Dept. B-6 for free booklet listing properties of pipe and welding fitting and flange materials.

"Be sure you see the double tt"

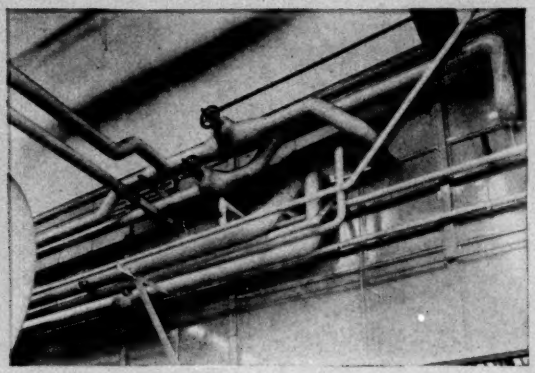
TUBE TURNS, INC. LOUISVILLE 1, KENTUCKY

DISTRICT OFFICES: New York • Philadelphia • Pittsburgh • Chicago • Houston • Tulsa • San Francisco • Los Angeles
TUBE TURNS OF CANADA LIMITED, CHATHAM, ONTARIO... A wholly owned subsidiary of TUBE TURNS, INC.

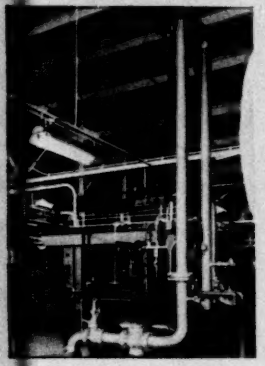
Penicillin processor welds stainless steel piping ½" and up



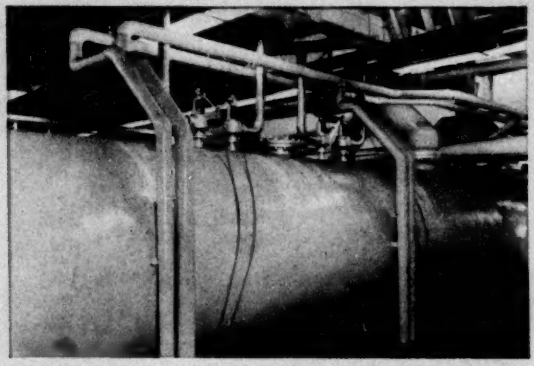
Advanced facilities in plants and laboratories help Eli Lilly and Co., Indianapolis, turn out a high volume of pharmaceuticals, biologicals, and antibiotics. This new filtration unit in the penicillin processing system uses 3" and 4" Type 316 stainless steel—chosen to resist corrosive action. Welded system with TUBE-TURN Welding Fittings and Flanges was chosen to provide maximum strength and eliminate leakage.



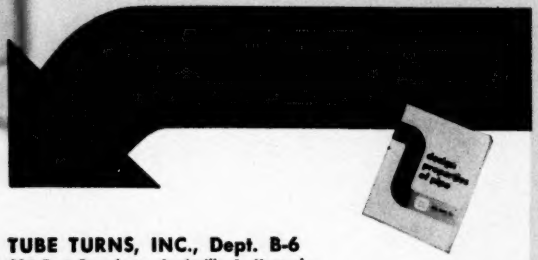
Neat appearance of insulated lines demonstrates simplicity of welded piping. Insulation was applied quickly over pipe and TUBE-TURN Welding Fittings, with no awkward joints to work around. Maintenance men know that insulation will last, with no leakage to cause deterioration. Cleanliness and neatness are prime requirements in Eli Lilly plants.



Up in the air goes a loop welded with 6" pipe, joined with TUBE-TURN Welding Fittings and Flanges. Structural strength here is a must. In this fermentation tank where life-saving penicillin is made, tiny lines of ½", as well as larger sizes, are welded. Comparable modern facilities are provided for making streptomycin and other products.



Lines to process vessel fit neatly into a small space when TUBE-TURN Welding Elbows make the turns. Eli Lilly engineers specified process piping for optimum flow conditions, compactness, and elimination of leakage.



TUBE TURNS, INC., Dept. B-6
224 East Broadway, Louisville 1, Kentucky

Your Name .....
Position .....
Company .....
Nature of Business .....
Address .....
City ..... *State* .....

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New York	Houston
Philadelphia	Tulsa
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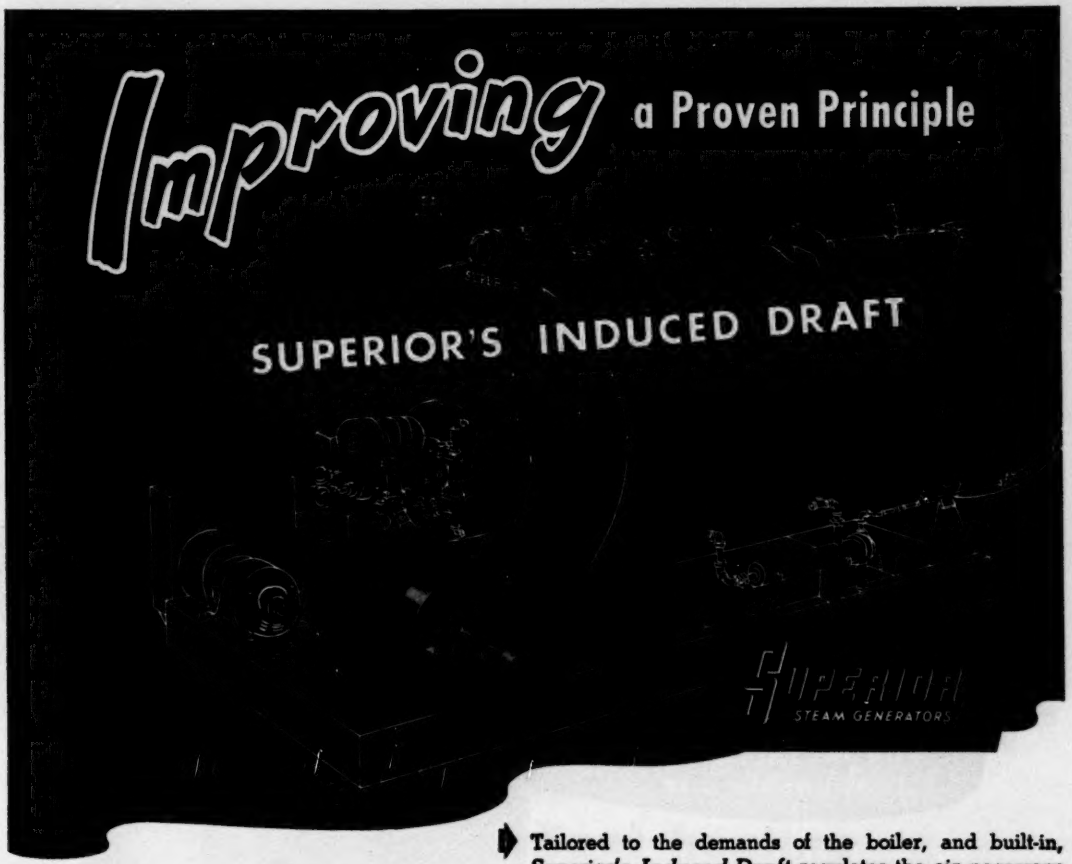
TUBE TURNS, INC.

LOUISVILLE, KENTUCKY

Improving a Proven Principle

SUPERIOR'S INDUCED DRAFT



Built to operate on the same proven principle as natural draft, Superior's *Induced Draft*, because of its built-in design, low-speed fans, and unique construction, assures maximum boiler capacity at high efficiency. It provides accurate control of draft conditions without the usual disadvantages of mechanical draft. Cleaner, quieter, and safer in every respect, it represents but one of the many "Designed by Demand" features which contribute to the overall efficiency and long life of Superior Steam Generators.

Superior Steam Generators are shipped completely assembled, backed by undivided responsibility • Burn gas or oil, or both • 18 sizes from 20 to 600 b.h.p. for pressures up to 250 p.s.i. or for hot water • Write today for Catalog 319.

- Tailored to the demands of the boiler, and built-in, Superior's *Induced Draft* regulates the air necessary for efficient combustion. Leaves front platform clear.
- Full-width fan construction minimizes the danger of overworked or burnt-out tubes by providing an even draw across the entire tube area of the boiler.
- *Induced Draft* eliminates the danger of forcing the products of combustion into the boiler room to spread dust, dirt, and unhealthful air throughout the building.
- Especially-designed over-size fans run slower, minimizing wear and maintenance.
- Quieter, low-speed fans eliminate the high-pitched whine commonly associated with forced mechanical draft.
- Long-lived trouble-free operation assured by corrosion-resistant fans with outboard mounted bearings located out of the path of combustion gases.
- Eliminates the expense of a large chimney.

uperior ombustion ndustries, inc.

6 gpm

will pay for a new model

New Model 23

MARLEY

Aquatower

FOR INSTALLATION
INDOORS OR OUT

Models 23 and 33—newest in the complete Aquatower line—are specifically designed to save 90 per cent of the water charges on two to six-ton refrigeration installations. Even a 6 gpm service can use 250,000 gallons per month, so an Aquatower is a truly profitable investment in most cities. Aquatowers conform to all building code requirements. They are simple in design, foolproof in operation—distinct advantages to the average owner of a small installation.

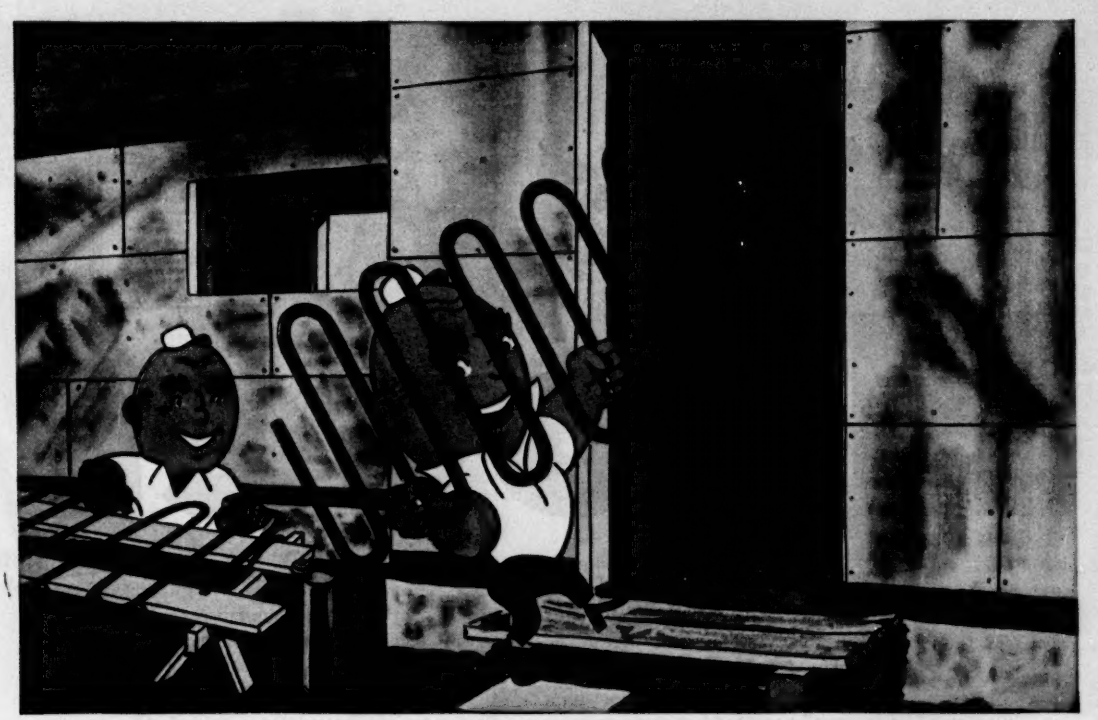
New Model 33

Also producers of

VAIRFLO TOWERS
NATURAL DRAFT TOWERS
DOUBLE-FLOW TOWERS
DRICOOLERS
SPRAY NOZZLES

MARLEY

The Marley Company, Inc.
KANSAS CITY 15, KANSAS



Bundyweld . . . right in your homes for better radiant heating

Unique construction, unique advantages—that's why!

Bundyweld is the only tubing double-walled from a single strip. It's extra-strong. Copper-brazed through 360° of wall contact, it's leakproof. It's double-walled, yet thinner-walled . . . *right* for faster-heating, more effective systems in your houses.

It's *right* for easier handling, too, on your building site. From its arrival in twenty-foot lengths (one end expanded when specified) to final installation in your ceilings, walls, or floors, tough Bundyweld rides over jolts, knocks, and jars. On a simple fixture, one man easily bends ductile Bundyweld to short radii, with no danger of structural collapse. Formed grids are easily joined, joined grids quickly positioned.

Briefly, when Bundyweld goes to work on your job, time, labor, materials savings, and better all 'round radiant heating go with it. Check Bundyweld today. For details, see *Sweet's Architectural File.* Or write: ***Bundy Tubing Company, Detroit 14, Michigan.***

Bundyweld® Tubing

DOUBLE-WALLED FROM A SINGLE STRIP

WHY BUNDYWELD IS BETTER TUBING

Bundyweld starts as a single strip of basic metal, coated with a bonding metal. Then it's . . .

continuously rolled into a tube of uniform thickness, and

passed through a furnace. Bonding metal fuses with basic metal, producing

Bundyweld . . . double-walled and brazed through 360° of wall contact.

NOTE the exclusive patented Bundyweld beveled edge, which affords a smoother joint, absence of bead and less chance for any leakage.

If your reputation thrives on warm air...

Hoover®

Electric Motors help it grow...

When you specify, install or service furnace blowers, your good name is like an orchid. It depends on warm air. In fact the blowers must deliver warmth reliably and without fail, both for your customers' sakes and yours. That's why it's wise to rely on Hoover Motors!

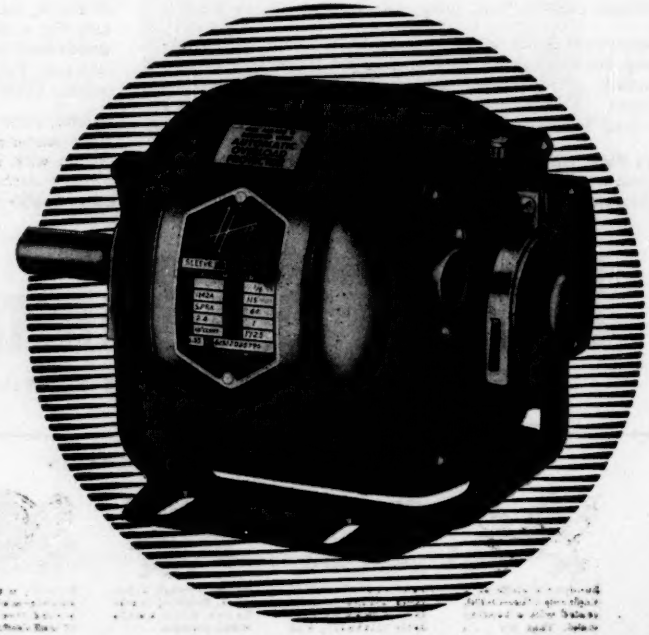
Hoover furnace blower motors give smooth, quiet, dependable service. They're dripproof, equipped with automatic thermal protection, designed for a 40° C. temperature rise. They're built like motors costing far, far more.

They come in different HP ratings, both split-phase and capacitor-start. So there's sure to be a Hoover Motor to fit any furnace blower you install or service —a Hoover Motor to help that blower satisfy your customer, to help your reputation grow!

Hoover Furnace Blower Motors available in ratings of ⅙ HP through ⅓ HP split-phase, and ½ HP through ¾ HP capacitor-start. All feature 1725 RPM speed, Gits oilers and a resilient base built to meet NEMA mounting standards. Automatic thermo protectors have been checked and approved by Underwriters' Laboratories.

Write today for complete information—on furnace blower motors or on motors built for other purposes.

THE HOOVER COMPANY
Kingston-Conley Division
68 Brook Avenue
North Plainfield, New Jersey



Now small and large

No. 33 SAFETY RELIEF VALVE

FOR HOT WATER BOILERS UP TO 242,900 BTU/HR OUTPUT

Opening pressure, 30 lbs. Discharge capacity covers most hot-water heating boilers.

No. 233 ASSEMBLY

FOR BOILERS UP TO 496,700 BTU/HR OUTPUT

Consists of two No. 33 Series valves mounted on manifold. First valve opens at 30 lbs.; second at 33 lbs.

No. 333 ASSEMBLY

FOR BOILERS UP TO 769,400 BTU/HR OUTPUT

Consists of three 33 Series valves mounted on manifold. First valve opens at 30 lbs; second at 33 lbs.; third at 36 lbs.

Authority speaks — Here is a straight forward statement from a recent bulletin issued by the highest authority on pressure vessel safety:

> "If a user wishes to protect a hot-water supply boiler or a hot-water heating boiler, the rules outlined in the 1949 A.S.M.E. Low-Pressure Heating Boiler Code and the 1950 Addenda thereto should be followed. In brief those rules require that all hot-water heating boilers and all hot-water supply boilers be equipped with *rated* relief valves. The relieving capacity of these rated relief valves should be equal to the heat output of the hot-water heating boiler or the hot-water supply boiler."

Every good heating man wants to conform to this regulation. As you no doubt know it was put into effect because the only sure way to protect a hot-water heating boiler from the disastrous overpressures produced by "runaway" firing is to provide a valve having a heat discharge capacity equal to the gross heat output of the boiler on which it is installed.

To conform with this ruling, it is only necessary to determine the heat output of the hot-water heating boiler; then equip it with a valve having equal or greater heat discharge capacity. This is easy when you equip it with a McDonnell 33 Series Safety Relief Valve. Each McDonnell Valve has its capacity in Btu. per hr. plainly shown on its name plate. The A.S.M.E. symbol is your proof that it has complied with all testing procedures outlined in the code.

As shown above, a single No. 33 Valve has a discharge capacity sufficient for about 70% of all boilers. But there still remains the larger boilers that need protection equally, and for these we have developed the No. 233, two-valve and No. 333, three-valve assemblies illustrated above. Thus you can now have McDonnell protection for boilers of larger size.

The No. 233 and 333 assemblies consist of two or three Series 33 valves mounted on manifolds as shown. They are packaged completely assembled on the manifolds, ready for easy installation. Their opening pressures are set so that they open successively—first valve at 30 psi, second valve at 33 psi and third (if 333 assembly is used) at 36 psi. By this method it is possible to retain the basic advantage of 33 Series valves —low discharge rate with small orifice to take care of normal thermal expansion and high discharge rate to take care of a high temperature condition of overfiring. This is explained opposite. In contrast, if a single high capacity valve is utilized, the opening of a large orifice on thermal expansion will result in a needless large discharge rate that can easily be avoided by using a small easier-to-close orifice of the 33 design.

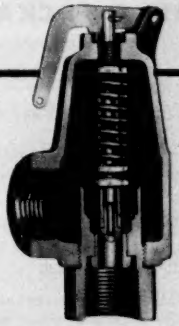
Complete details covering application and installation of No. 233 and 333 Assemblies are covered in a new bulletin. Basic facts are all given in the new McDonnell Condensed Catalog and Price List. Write.

McDONNELL & MILLER, Inc., 3500 N. Spaulding Ave., Chicago 18, Ill.

Doing One Thing Well

Your Jobber Stocks Them

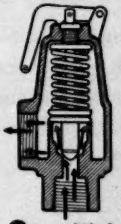
McDONNELL



McDonnell 33 Series Safety Relief Valves are built to comply with the A.S.M.E. Boiler Code and have been tested and rated by the National Board of Boiler and Pressure Vessel Inspectors.

They have ideal operating characteristics:

1. Low discharge rate for normal operation

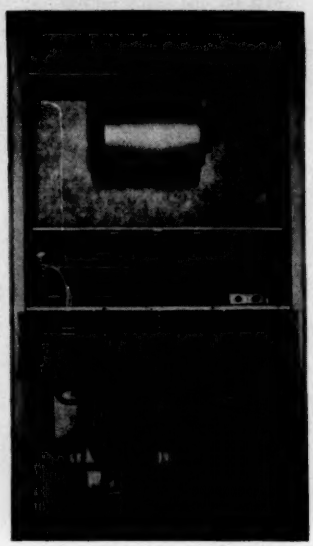


When boiler pressure reaches set opening pressure valve cone lifts just far enough to discharge water at low rate necessary to take care of thermal expansion. This advantage is retained whether one, two, or three valves are used.

2. High discharge rate for emergency operation

If for any reason steaming condition occurs, increased velocity acts on ingenious "Hydra-lift" disc, lifting valve wide open with snap action and discharging full rated capacity. Any emergency condition causes full opening whether one, two, or three valves are used.

EVERYTHING YOUR CUSTOMER WANTS



IN A PACKAGE AIR CONDITIONER

Here are the reasons why your customer will be happy with his Worthington Package Air Conditioner:

QUIET—acoustically insulated cabinet . . . no belts to wear or get out of line.

VIBRATION-LESS—smooth-floating multi-mounted compressor . . . dynamically-balanced fan.

TROUBLE-FREE—compressor hermetically-sealed against dust and moisture . . . no pulleys, couplings or seals.

NO ATTENTION NEEDED—pressure-type oiling . . . never needs replenishing.

LONG LIFE—compressor surfaces finished to micro-inch accuracy . . . oversize bearings . . . four rings per piston . . . dynamically-balanced crankshaft.

SAFE—high-pressure cut-out . . . high temperature safety switch.

CONVENIENT—finger-tip selection of temperature . . . thermostatic control . . . finger-tip adjustment of louvres.

ATTRACTIVE—plastic baked-enamel finish, scratch-resisting, washable . . . rounded corners, no projections . . . no "sweating".

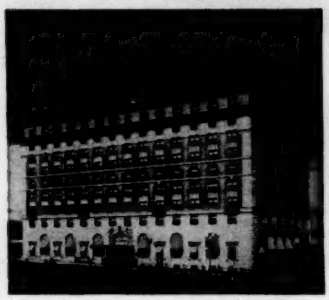
ECONOMICAL—thermally-insulated . . . large copper-finned cooling coils . . . Worthington Feather* Valves.

Each Worthington unit—3, 5 and 7½ ton sizes**—is built to the same high quality standards as Worthington equipment for engineered systems, such as those described at the right. *Write for Bulletin C1100-B29.*

*Reg. U. S. Pat. Off. **Also, for remote location: 7½, 10, 15, 20, 25 ton units

Another "Worthington-Conditioned" hotel

in the National Hotel Co. chain



The 400-room Washington Hotel, one of the leading hotels in the nation's capital, gets its air conditioning from a Worthington centrifugal refrigeration system, using chilled water. This is one of five National Hotel Company hotels to be Worthington-conditioned; the others are Hotel Jung, New Orleans; Travis Hotel, Dallas; Thomas Jefferson Hotel, Birmingham; Hotel Cortez, El Paso.

Off-and-On heat calls for Off-and-On cooling

The work performed in the research laboratory of Aluminum Company of America, East St. Louis, Ill., is of such a nature that excessive heat is produced intermittently.

Certain of the rooms are provided with a "wild zone" of air conditioning which goes into operation automatically when the heat-producing equipment is in use, and the normal air conditioning zone cannot handle the load.

This building is handled by a 125-ton Worthington air conditioning system comprised of two Freon-12 compressors and one evaporative condenser.

WORTHINGTON

AIR CONDITIONING AND REFRIGERATION

INVESTIGATE

MORE WORTH WITH WORTHINGTON

Consult Classified Telephone Directory for nearest Worthington distributor. Worthington Pump and Machinery Corporation, Air Conditioning and Refrigeration Division, Harrison, N. J., specialists in air conditioning and refrigeration for more than 50 years.

A1.3

HOFFMANIZE with a VENTING VALVE for EVERY NEED

RADIATOR VENTS • VACUUM • NON-VACUUM

2A
Vacuum Valve with 6 adjustable Vents. Hinged tongue siphon. Double Air-Locks. Size conn: ⅜".

1A
Non-Vacuum Valve. Six adjustable Vent Ports. Hinged tongue siphon. Size conn: ⅜".

70A
Single port, non-vacuum. Meets Fed. Spec. WW-V-151. Size conn: ⅜".

40
Single port, non-vacuum. Fine valve for low priced field. Size conn: ⅜".

MAIN VENTS • VACUUM • NON-VACUUM

75-75A
Non-vacuum. 75 for venting medium size systems, 75A for larger systems. Size conns: ¾" male, ½" female.

4A
Non-vacuum. For venting air from small steam systems. Size conn: ¾" male, ½" female.

4
Non-vacuum. For small steam mains. Has no float. Size conn: ¾" male, ½" female.

76-76A
Vacuum Valves having Double Air-Locks. 76 for venting medium size systems, 76A for larger systems. Size conn: ¾" male, ½" female.

16A
Vacuum Valve for venting mains of small systems. Has Double Air-Locks. Size conn: ¾" male, ½" female.

HOFFMAN

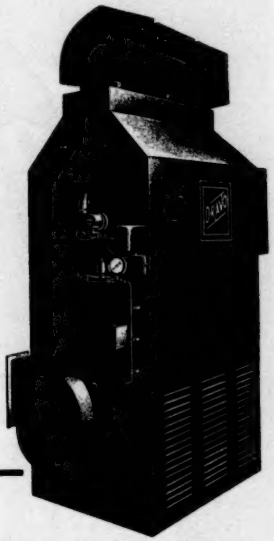
VALVES, TRAPS, HOT WATER HEATING SYSTEMS
VACUUM AND CONDENSATION PUMPS

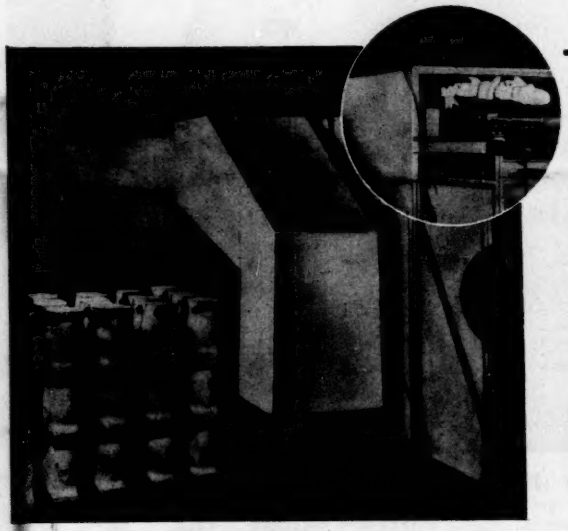
SOLD BY LEADING WHOLESALERS OF HEATING EQUIPMENT

HOFFMAN SPECIALTY COMPANY
1001 York St., Dept. HV-8, • Indianapolis 7, Ind.

"We cut processing time 55% by using DRAVO 'COUNTERFLO' Heaters in our medium-temperature curing and drying operations"*

*says . . . Mr. Eugene Salinger, Executive Vice President of Bayshore Industries, Elkton, Maryland





Here's how many Process Industries can profitably use DRAVO HEATERS

Although the major use of Dravo "Counterflo" Heaters is for space heating, these versatile heaters can easily be adapted to nearly any type of medium-temperature process drying and curing operations. Automatic temperature controls keep the hot air flow at required temperatures. Heaters warm up and cool down quickly; air can be recirculated, moisture-content of the air is controlled or removed entirely.

Here's where DRAVO Heaters are at work in medium-temperature process operations

- Curing and drying farm crops
- Drying wood containers
- Processing fibre containers
- Curing concrete pipe lining
- Curing in paper-making
- Processing of plastic toys
- Paint drying—automotive
- Paint drying—steel drums
- Kiln drying of wood products
- Curing neoprene backing of rugs
- Drying rugs after cleaning
- Auto "laundry" drying

Here's how BAYSHORE Industries profits by using Dravo Heaters

This leading manufacturer of rubber toy face masks uses two Dravo "Counterflo" Heaters, one on each of its production lines, to produce and circulate hot air at medium temperatures that dries and cures 66,000 masks daily.

The process consists of a conveyor system which moves through a duplex oven where temperatures are kept constant at 350° F. and 160° F., respectively. In addition to removing the 40% water content of the rubber mixture, the Dravo Heater cures rubber face masks in this 27-minute process, a 55% time reduction over the previous method used; this improved method of curing and drying has helped reduce the cost-per-mask.

Here's what DRAVO Heaters offer you

—Low initial cost . . . users report 50% to 60% savings.
—Heat delivery quickly and automatically adjusted to varying load requirements.
—Low Fuel consumption . . . burn gas or oil . . . easily converted.
—Automatic Control . . . on-off or modulating controls.
—Long service life, low maintenance . . . stainless steel combustion chamber.
—Mobility . . . easily moved to any location.
—Availability . . . immediate delivery . . . no delays.

WRITE FOR MORE INFORMATION—If you have a process heating and drying problem, it will be worth your while to look to Dravo "Counterflo" Heaters as a possible solution. Write today for booklet No. MN-526-46

DRAVO CORPORATION
HEATING DEPARTMENT, DRAVO BUILDING, PITTSBURGH 22, PA.
PITTSBURGH • CLEVELAND • PHILADELPHIA • DETROIT • NEW YORK • CHICAGO • ATLANTA • BOSTON
Sales Representatives in Principal Cities

Manufactured and sold in Canada by Marine Industries, Ltd., Sorel, Quebec

EXPORT ASSOCIATES, LYNCH, WILDE & CO., WASHINGTON 9, D. C.

Tri-Flex Aerovane

in 525 William Penn Place Building

Pittsburgh, Pennsylvania

Architects, engineers, contractors — planners and builders of tomorrow — choose their materials with care. The quality of the completed job depends on them. And the specialists responsible for the successful, dependable operation of an air conditioning system pay strict heed to the proper selection of the air distribution equipment... *the point where success is measured.*

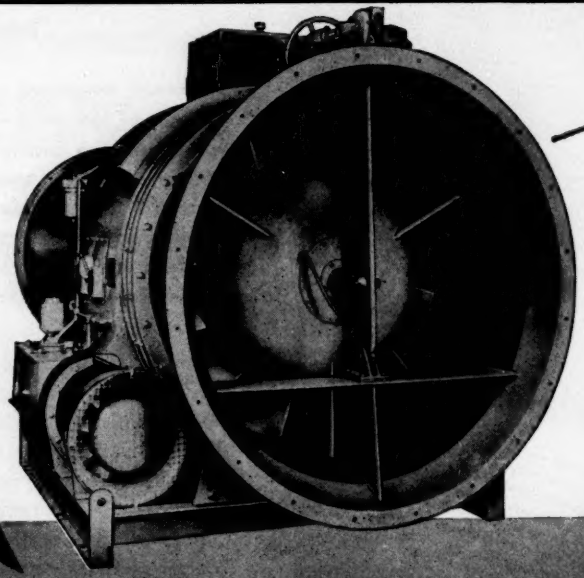
In the 525 William Penn Place Building — as in important buildings from coast to coast — the choice was the outstanding combination of Tri-Flex and Aerovane Grilles and Registers... the combination that insures maximum flexible control of air delivery ... meets the most exacting requirements of performance. For consistent quality that guarantees the results, standardize on Tri-Flex and Aerovane. For complete information, write for Catalog 48S.

TUTTLE & BAILEY inc

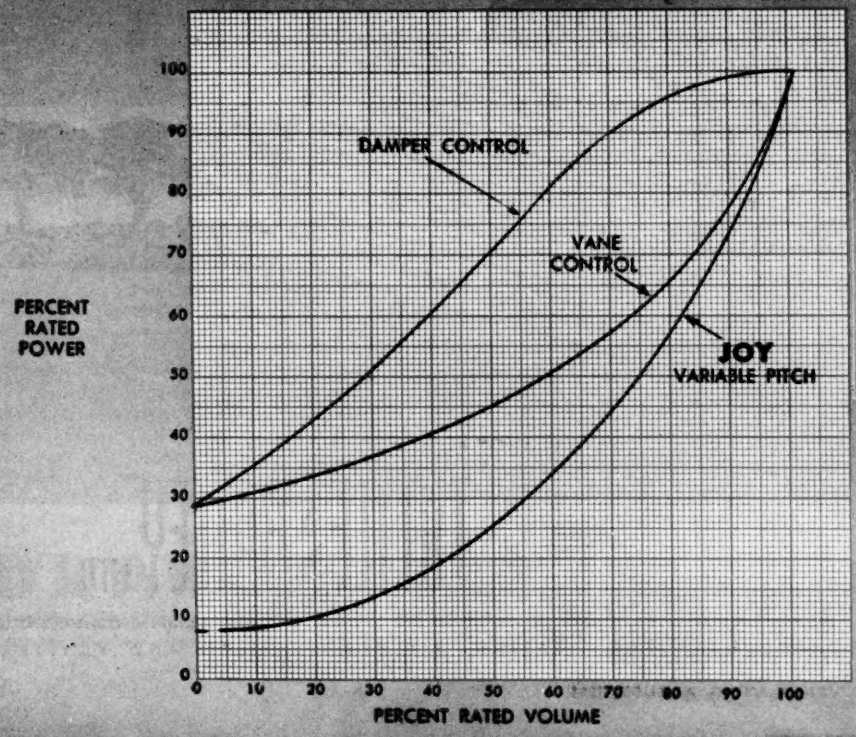
NEW BRITAIN, CONNECTICUT

ENGINEERED PRODUCTS FOR HEATING, AIR CONDITIONING AND VENTILATING

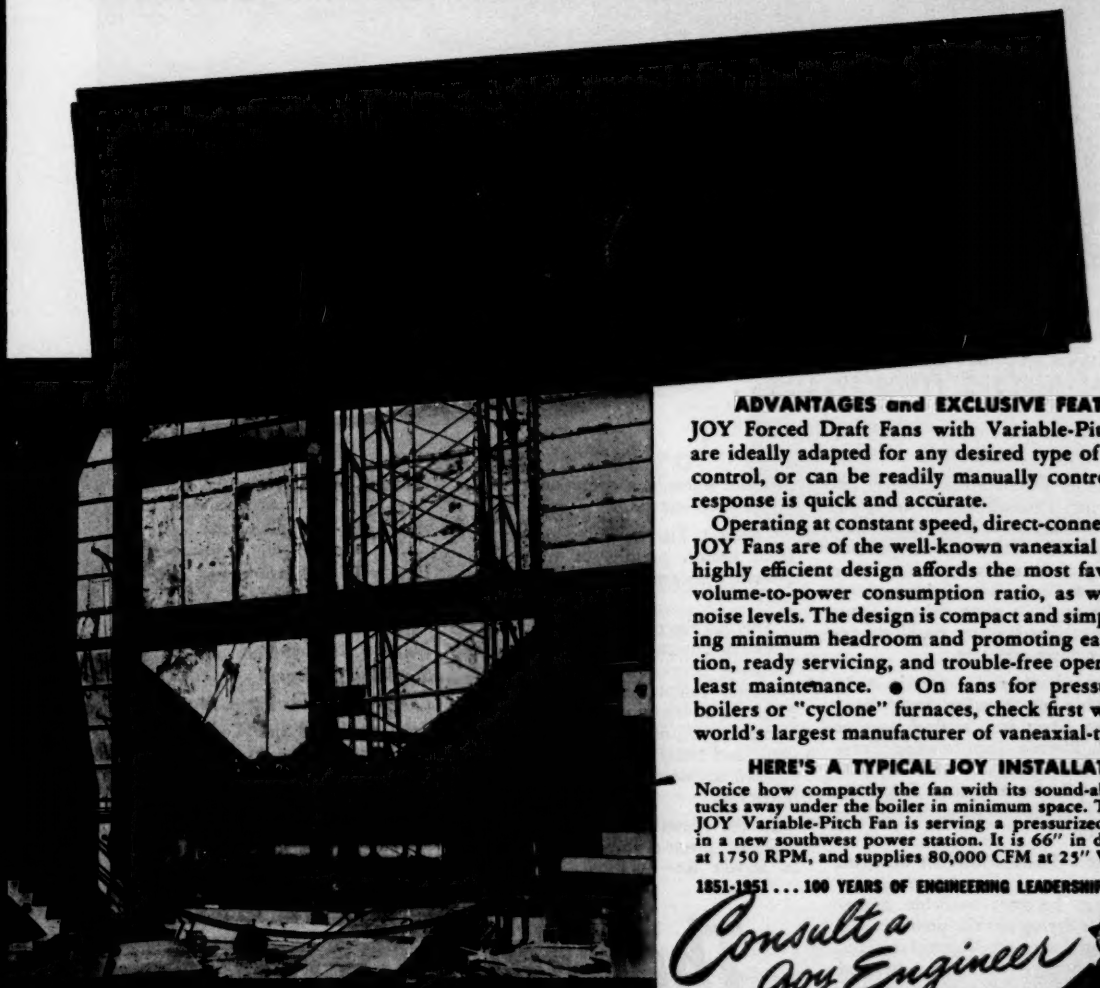
Look How You Can SAVE POWER at REDUCED VOLUMES...



COMPARISON CURVES OF VOLUME CONTROL METHODS



...with JOY AXIVANE® FORCED DRAFT FANS



ADVANTAGES and EXCLUSIVE FEATURES

JOY Forced Draft Fans with Variable-Pitch Blades are ideally adapted for any desired type of automatic control, or can be readily manually controlled. The response is quick and accurate.

Operating at constant speed, direct-connected, these JOY Fans are of the well-known vaneaxial type. This highly efficient design affords the most favorable air volume-to-power consumption ratio, as well as low noise levels. The design is compact and simple, requiring minimum headroom and promoting easy installation, ready servicing, and trouble-free operation with least maintenance. ● On fans for pressurized-type boilers or "cyclone" furnaces, check first with JOY—world's largest manufacturer of vaneaxial-type fans.

HERE'S A TYPICAL JOY INSTALLATION

Notice how compactly the fan with its sound-absorbing set tucks away under the boiler in minimum space. This 400 HP JOY Variable-Pitch Fan is serving a pressurized-type boiler in a new southwest power station. It is 66" in dia., operates at 1750 RPM, and supplies 80,000 CFM at 25" WG.

1851-1951 ... 100 YEARS OF ENGINEERING LEADERSHIP

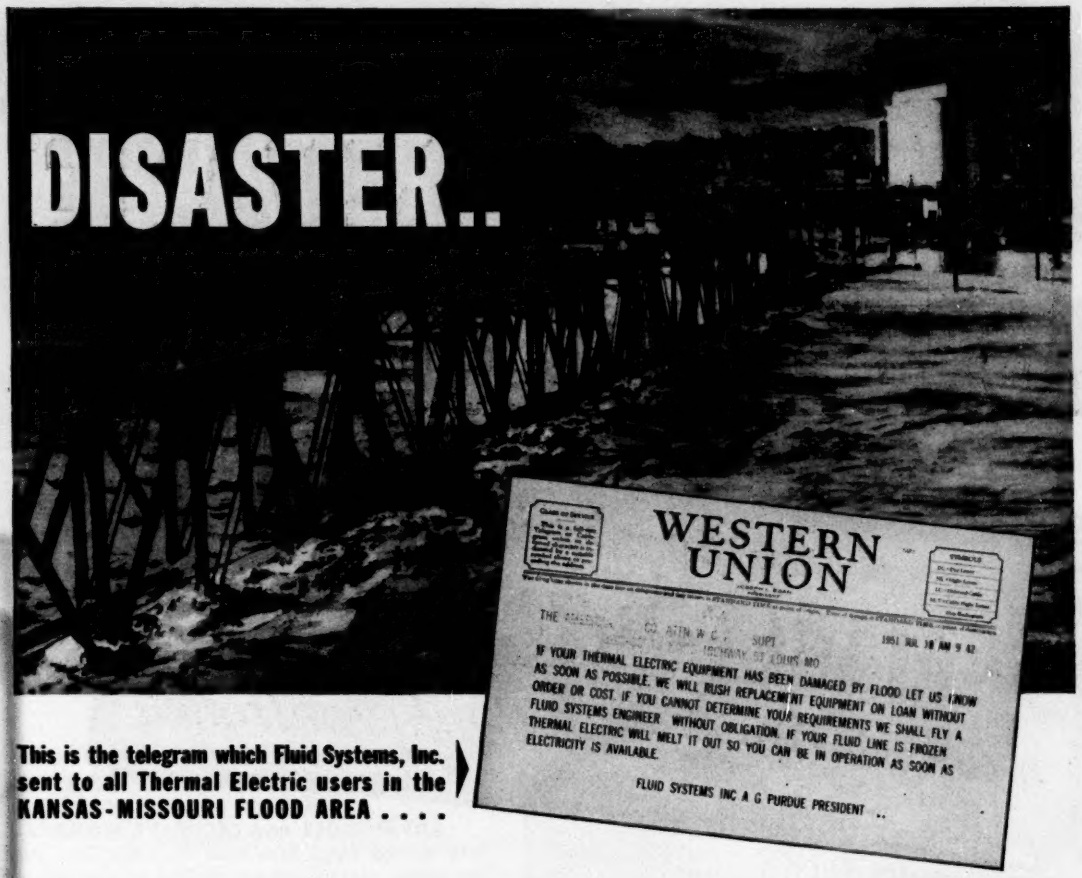
Consult a Joy Engineer

WAD 13694

JOY MANUFACTURING COMPANY

GENERAL OFFICES: HENRY W. OLIVER BUILDING · PITTSBURGH 22, PA.

IN CANADA: JOY MANUFACTURING COMPANY (CANADA) LIMITED, GALT, ONTARIO


DISASTER..
WESTERN UNION
IF YOUR THERMAL ELECTRIC EQUIPMENT HAS BEEN DAMAGED BY FLOOD LET US KNOW AS SOON AS POSSIBLE. WE WILL RUSH REPLACEMENT EQUIPMENT ON LOAN WITHOUT ORDER OR COST. IF YOU CANNOT DETERMINE YOUR REQUIREMENTS WE SHALL FLY A FLUID SYSTEMS ENGINEER WITHOUT OBLIGATION. IF YOUR FLUID LINE IS FROZEN THERMAL ELECTRIC WILL MELT IT OUT SO YOU CAN BE IN OPERATION AS SOON AS ELECTRICITY IS AVAILABLE.
FLUID SYSTEMS INC A G PURDUE PRESIDENT

This is the telegram which Fluid Systems, Inc. sent to all Thermal Electric users in the KANSAS-MISSOURI FLOOD AREA . . . .

Just picture this: As flood waters began to rise, Thermal Electric users did not have to maintain steam in the face of impossible difficulties to prevent freeze-up of their wax, asphalt or other fluid lines. They did not have to remember to drain them, with a thousand other simultaneous problems demanding their attention.

Afterward, they did not have to disassemble or re-erect their fluid transport. They just hooked another Thermal Electric Transforming Energizer to the pipe, and production proceeded while Fluid Systems Engineers dried out the flood-soaked unit for reinstallation.

Where a Thermal Electric Standard System is part of the oil burning layout, steam becomes available immediately for drying out the premises and for essential services. Thermal Electric melts the bunker fuel in the pipes and in storage. If old fashioned steam systems had been used, waterlogged remote pump-sets could not have maintained constant circulation and no steam could have been available for days to heat the fuel. Thermal Electric provides immediate operation as soon as the flood recedes.

Thermal Electric's flexible equipment design permits us to furnish disaster replacements immediately from stock.

Thermal Electric has helped in many disasters. Thermal Electric was used in restoring service to Southern New England Telephone Company, New England Telephone and Telegraph Company, United Illuminating Company, and many companies along the Atlantic Seaboard after two devastating hurricanes.

In the Kansas-Missouri flood area, Thermal Electric speeded the return of service for—

Owens-Corning Fiberglas Corp.
915′ of 375°F. asphalt transfer
American Can Company
140′ of 425°F. asphalt transfer
Blanke-Baer Extract and Preserving Company
Eden Seminary
Marillac Seminary
Stephens College
Enterprise Cleaning Company
Sears-Roebuck and Company

Fluid System's engineers are a service team. No cost or effort is spared to maintain continuous and dependable performance. Direct contact with home office personnel insures service without delay at all times.

PAT. NO. 2,224,409

Thermal Electric

FLUID SYSTEMS, INC., 1881 DIXWELL AVE., NEW HAVEN 14, CONN.

Fluid Systems INC.

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demand DETROIT CERTIFIED CONTROLS

ONLY DETROIT OFFERS

TIMED CYCLING WITH THE ADJUSTABLE PARALLEL HEATER...

TIMED CYCLING
Gives Your Customers

Uniform room temperature—controlled within a fraction of a degree • Elimination of the waste and discomfort of over and under heating • Greater fuel economy • Automatic adjustment of heating to all existing influences, such as outside temperature, wind direction and velocity, solar radiation, etc. • Geared-to-the-weather heating.

a turn of a screw

tailors temperature control to fit any installation!

DETROIT'S No. 411-CH *Timed Cycling* Thermostat is a natural for all your new installation and conversion jobs. Equipped with an easily adjustable parallel heater, the No. 411-CH can be swiftly adapted with minimum effort to provide maximum comfort under a wide variety of installation conditions. With a simple turn of a screw, cycles can be shortened or lengthened to fit the specific installation without disturbing the factory settings. Because the unique *Timed Cycling* parallel heater is not affected by variations in the electrical load, this remarkable thermostat may be used on *all* types of installations and is particularly well adapted to conversion burner work where the heating unit is either over or under size. In addition, the *Timed Cycling* Thermostat eliminates the need to select a special heater by giving you *one* heater adaptable to *all* jobs. This exclusive feature greatly simplifies inventory, installation and service problems and assures your customers the utmost in heating comfort. For complete information see your DETROIT wholesaler today.

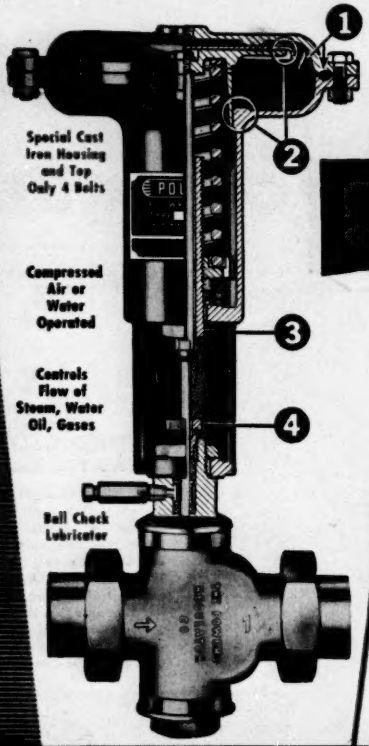
Write for Form No. 1545

DETROIT
LUBRICATOR COMPANY

5900 TRUMBULL AVE., DETROIT 8, MICHIGAN
Division of American Radiator & Standard Sanitary Corporation
Canadian Representatives: RAILWAY & ENGINEERING SPECIALTIES, LTD.—Montreal, Toronto, Winnipeg

DETROIT HEATING AND REFRIGERATION CONTROLS • ENGINE SAFETY CONTROLS • FLOAT VALVES AND OIL BURNER EQUIPMENT • DETROIT EXPANSION VALVES AND REFRIGERATION ACCESSORIES • STATIONARY AND LOCOMOTIVE LUBRICATORS

Pioneering Home and Industry. AMERICAN-STANDARD • AMERICAN BLOWER • CHURCH SEATS • DETROIT LUBRICATOR • KEWANEE BOILERS • ROSS HEATER • [illegible]



POWERS
LOWRITE
VALVE

VE TOP—Durable moulded neoprene diaphragm (1) has positive sealing bead which provides increased sealing action with increasing control pressure. Efficient diaphragm form insures ample and constant operating power thru full travel. Piston Plate Assembly (2) has a free floating thrust plate which absorbs side thrust. Closely guided piston plate maintains stem in accurate alignment.

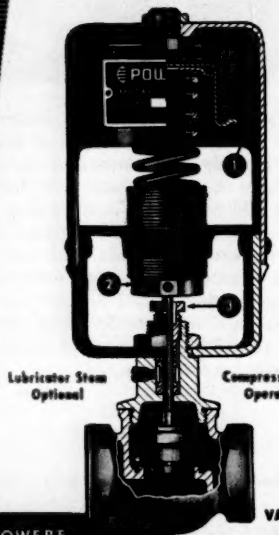
ADJUSTING SCREW—Ball bearing non-rising type. Easily accessible, 180° turning radius with starting pressure adjustable from 0 to 17 psi. Has enclosed rust proofed steel spring for full travel in 5 or 10 psi. control pressure change.

BONNET ASSEMBLY—Polished stainless steel stem in preformed lubricated metallic packing insures long life and low hysteresis.

VARIETY of VALVE BODIES — Sizes ½" thru 8"—For line pressures below 250 psi. Rugged construction to withstand piping strains. Single seat or double seat, bronze and stainless steel trim. Double unions and flanged ends. Available normally open (direct acting) or normally closed (reverse acting) and 3-way type valves.

POWERS BETTER Valve Tops

Packless Valves Available



POWERS
ETAFLOW
VALVE

VALVE SIZES— ½" thru 2"
Bronze bodies, screwed ends. Rugged construction to withstand piping strains.

POWERS *Metaflow Valves* are small, sturdy, light-weight, reasonably priced, suitable for many control applications where the pressure differential does not exceed 75 lbs. per square inch.

1. **HOUSING**—High strength aluminum alloy. Hydraulically formed long life brass bellows provides smooth and powerful stroke.

2. **ADJUSTING SCREW**—Brass with rust proofed steel spring having 15 lbs. adjustment range to give proper sequence operation where required.

3. **BONNET ASSEMBLY**—Polished stainless steel stem in preformed lubricated metallic packing insures long life and low hysteresis.

TRIM—Composition disc with brass integral seat and self-aligning disc holder. Available normally open (direct acting) or normally closed (reverse acting), and 3-way.

METAFLOW NO-PAK VALVES prevent leakage of inflammable or harmful liquids or gases and provide vacuum protection. Are suitable for use with Freon, oil, gasoline, non-corrosive gases, hot or cold water and low pressure steam.

Phone or Write Nearest Office for Prices

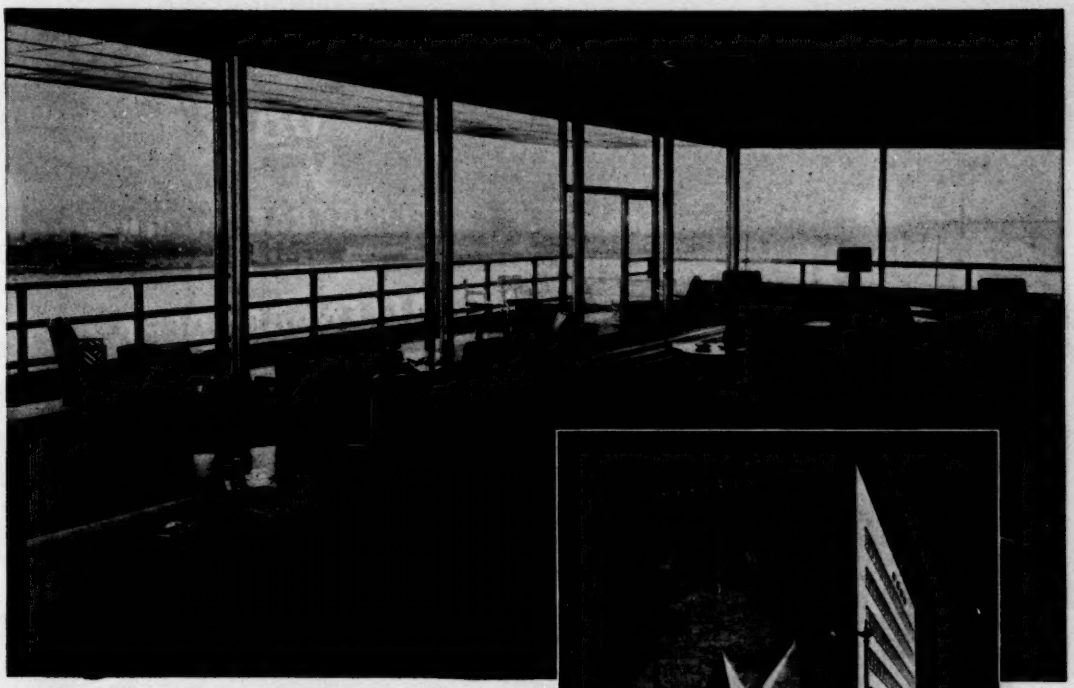
THE POWERS REGULATOR CO.

OFFICES IN OVER 50 CITIES • See Your Phone Book

CHICAGO 14, ILL., 2718 Greenview Ave. • **NEW YORK 17, N.Y.,** 231 E. 46th St.
LOS ANGELES 5, CAL., 1808 West 8th St. • **TORONTO, ONT.,** 195 Spadina Ave.
MEXICO, D. F., Edificio "La Nacional" 601

OVER 58 YEARS OF PNEUMATIC TEMPERATURE CONTROL

(FM3)



Lounge and exterior, Veterans Memorial Building, Detroit, Mich.
Architects and Engineers: Harley, Ellington & Day, Inc., Detroit, Mich.
General Contractors: Kuhne-Simmons Co., Inc., Detroit
Air Conditioning Contractors: American Refrigerating Co., Detroit

Simply beautiful

kno·draft adjustable air diffusers

In their beautiful simplicity of line, Kno-Draft Adjustable Air Diffusers are grace notes for any decorative theme. But unless you just happened to look ceilingward, you might not ever notice them in the modern lounge above. Nor would they be more obtrusive in period surroundings.

Certainly, Kno-Draft Adjustable Air Diffusers will never call attention to themselves by discomforting the occupants of any room. All that their name implies, Kno-Draft Adjustable Air Diffusers circulate air gently and *without draft* . . . keep temperature uniform throughout the conditioned area. Air volume and flow pattern are adjustable *after* installation . . . thus simplifying the engineering of the job as well as providing flexible control to meet both present and future conditions.

You'll find Kno-Draft Adjustable Air Diffusers in many of America's notable and architecturally significant buildings. Whatever the air conditioning requirements, there are types and sizes to meet them. Write us for detailed information.

KNO-DRAFT DATA BOOK: Complete specifications, engineering and installation data on Kno-Draft *Adjustable* Air Diffusers. To get your copy, simply fill in and mail the coupon. No obligation, of course.

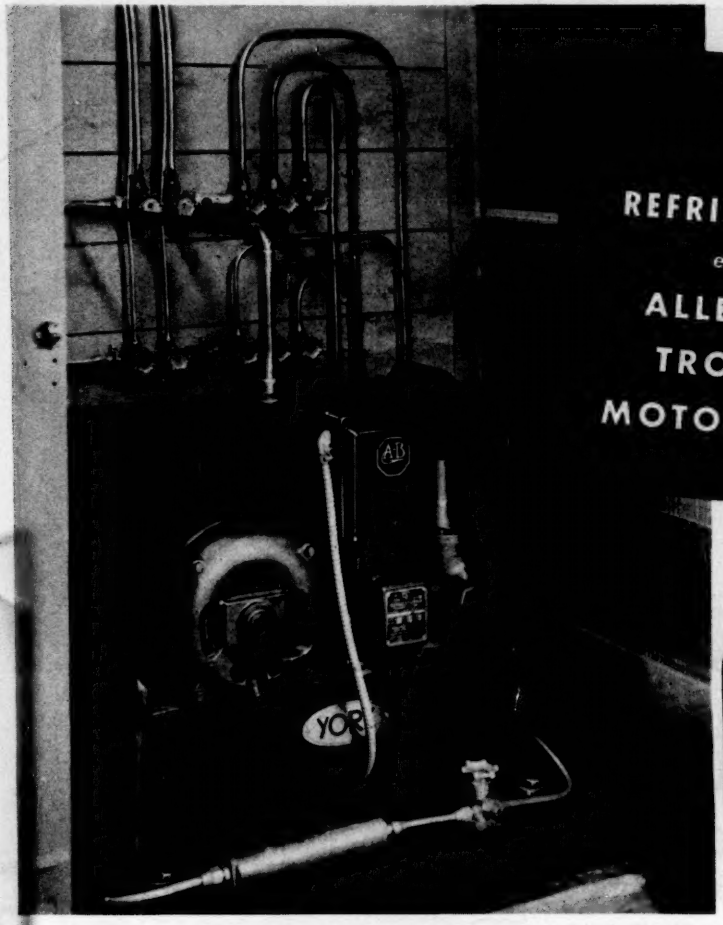
TRADE MARK "KNO-DRAFT" REG. U. S. PAT. OFF.

W. B. CONNOR ENGINEERING CORP.
Danbury, Connecticut
Air Diffusion • Air Purification • Air Recovery
In Canada: Douglas Engineering Co., Ltd.,
190 Murray Street, Montreal 3, P. Q.

W. B. CONNOR ENGINEERING CORP.
Dept. J-8, Danbury, Connecticut

Please send me, without obligation, my copy of the Kno-Draft Air Diffuser Data Book.

Name .....
Position .....
Company .....
Street .....
City ..... Zone ..... State .....



A York Compressor equipped with an Allen-Bradley Bulletin 709 Automatic Starter installed in an Atlantic and Pacific Store in Boston.

Why are Allen-Bradley starters so popular for refrigeration and air-conditioning service? . . . Because they are trouble free. Only ONE moving part. No pivots, pins, or bearings to corrode or stick . . . no jumpers to break. You install them . . . and forget them!

No contact maintenance . . . Allen-Bradley patented silver alloy contacts never need cleaning, filing, or dressing.

Dependable overload relays . . . Allen-Bradley thermal relays are accurate and always dependable . . . even after long service.

The Allen-Bradley trade-mark stands for millions of trouble free operations.

Allen-Bradley Co., 1330 S. Second St., Milwaukee 4, Wis.

A-B Bulletin 709 Solenoid Starter

Size 1 starter with cover removed. Dependable relays provide accurate overload protection. Note white interiors and ample space for ease of wiring.

A-B Special Refrigeration Control Unit

Consists of Bulletin 709 solenoid starter, Bulletin 836 high pressure cutout, Bulletin 837 thermostat with adjustable knob, and Bulletin 600 manual switch.

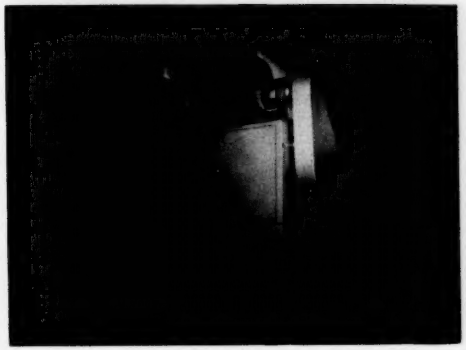
ALLEN-BRADLEY SOLENOID MOTOR CONTROLS

American Blower—a time-honored name in air handling

Look before you buy and you'll buy American Blower Air Handling Products. There's a big difference in quality, design, quietness, operating costs and efficiency. The superiority of American Blower products has been proved in test after test by buyers.

In Indianapolis, as in other cities, American Blower Air Handling Products serve commerce, industry and public utilities. For air handling data in the Indianapolis area, call American Blower—Riley 4521. Elsewhere, consult your phone book.

Product of the month



American Blower Industrial Unit Heater. 7 Sizes. Capacities from 1,900 to 28,000 cfm and from 79,000 to 1,630,000 Btu/hr.

Ideal for heating large areas

For heating large areas, such as factories, foundries, garages, warehouses, laundries, and machine shops, American Blower Industrial Type Unit Heaters are unsurpassed.

They're available in seven sizes for wall, horizontal, inverted or floor installation. Coils are offered in a wide range of capacities, and with the option of three coil designs—steam, hot water or freeze-resistant. Universal Cowls, adjustable on the job, direct air and heat to desired areas.

If you have a heating problem, consult your local American Blower Branch Office. They'll be glad to furnish you with further information about Industrial Heaters and the wide range of other reliable American Blower products for both heating and ventilating.

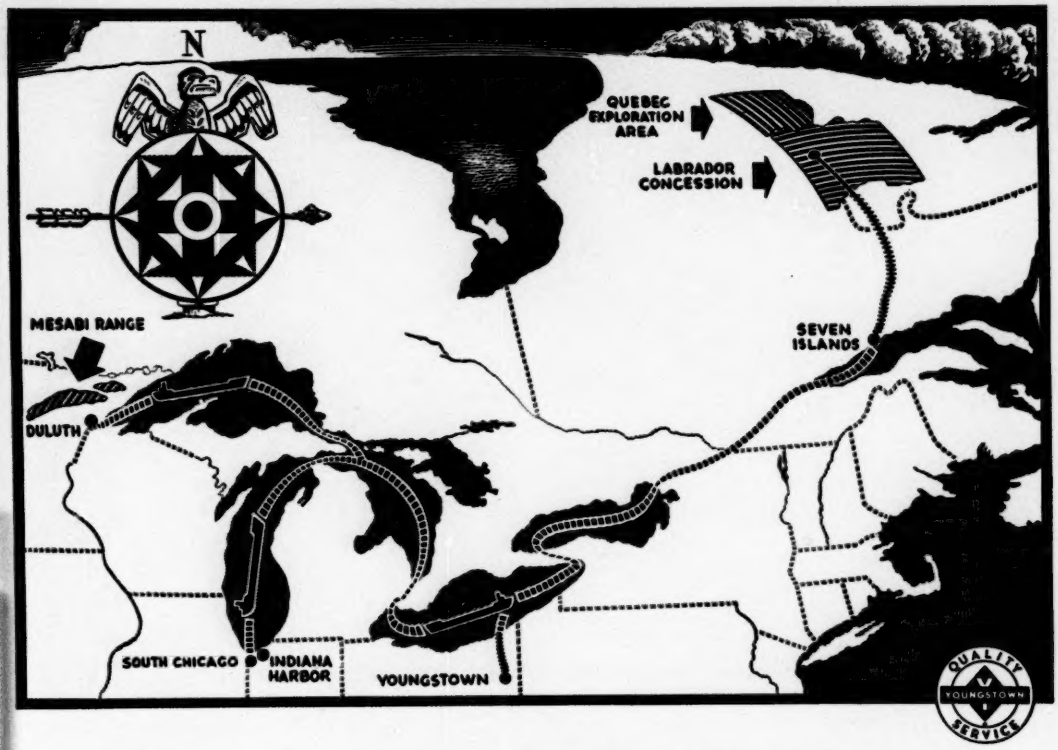
AMERICAN BLOWER CORPORATION, DETROIT 32, MICHIGAN
CANADIAN SIROCCO COMPANY, LTD., WINDSOR, ONTARIO

Division of American Radiator & Standard Sanitary corporation

YOUR BEST BUY AMERICAN BLOWER AIR HANDLING EQUIPMENT

Serving home and industry

AMERICAN-STANDARD · AMERICAN BLOWER · CHURCH SEATS · DETROIT LUBRICATOR · KEWANEE BOILERS · ROSS HEATER · TONAWANDA IRON



Mister, can you spare Half a Billion Dollars?

ONE half a billion dollars may seem like pin money compared to the sums mentioned for our national finances.

But it is more than three dollars for each man, woman and child in the United States. It is more than the entire steel industry earned in the "dreadful decade" from 1930 to 1939. It's more than America spent to win two wars--the War of 1812 and the Mexican War, combined.

Approximately one half a billion dollars is the estimated sum that a group of steel and mining companies, one of which is The Youngstown Sheet and Tube Company, is investing to guarantee future iron ore supplies for America. In the Mesabi iron range of Minnesota, development projects are under way which will produce millions of tons of iron concentrates from taconite. In Labrador and Quebec, a vast deposit of high grade ore is being developed. Plans include building a 360-mile railroad into the wilderness to ore docks on the St. Lawrence River.

Where does this money come from? From an unnoticed addition to our national debt? From "extra nickels" tucked away in the Federal budget? From more taxes levied on every citizen's income? *Certainly not!* Development of these ore reserves will be financed by each participating Company asking its shareholders to share in its tremendous cost.

America, in peace or in war, is served--now --and for generations to come. This is free enterprise. This is the system that created America from a wilderness and is the only sure way to keep it vigorous and strong.

Scrap Metal is Critical Again

The Youngstown Sheet and Tube Company

General Offices--Youngstown 1, Ohio
Export Offices--500 Fifth Avenue, New York
MANUFACTURERS OF CARBON ALLOY AND YOLOY STEELS

The steel industry is using all its resources to produce more steel, but it needs your help and needs it now. Turn in your scrap, through your regular sources, at the earliest possible moment.

They all depend on ANEMOSTAT

"Judge a product by those who use it." Apply this maxim to air diffusers and you have ample evidence why Anemostat Draftless Air Diffusers enjoy such overwhelming preference. This partial list of "those who use it" proves the point.

Many of these installations represented unique air diffusion problems which were successfully solved by Anemostat. This experience can be a valuable and practical aid to you. Your local Anemostat Sales Engineer is backed by the most experienced engineering department. Call him.

ALUMINUM COMPANY OF AMERICA
AMERICAN CAN AND FOUNDRY COMPANY
AMERICAN CYANAMID COMPANY
B & O RAILROAD
BETHLEHEM STEEL CORPORATION
BOEING AIRCRAFT COMPANY
CHASE NATIONAL BANK
CHRYSLER CORPORATION
CHRYSLER MOTORS CORPORATION
CONSOLIDATED VULTEE AIRCRAFT CORPORATION
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N. Y. CENTRAL'S STREAMLINER "CHIEF"
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ROCKEFELLER CENTER
SANTA FE RAILROAD
SEARS-ROEBUCK & COMPANY
STANDARD OIL COMPANY
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U. S. ATOMIC ENERGY COMMISSION
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WESTINGHOUSE ELECTRIC CORPORATION
WOOLWORTH STORES
AND A THOUSAND OTHERS OF EQUAL IMPORTANCE

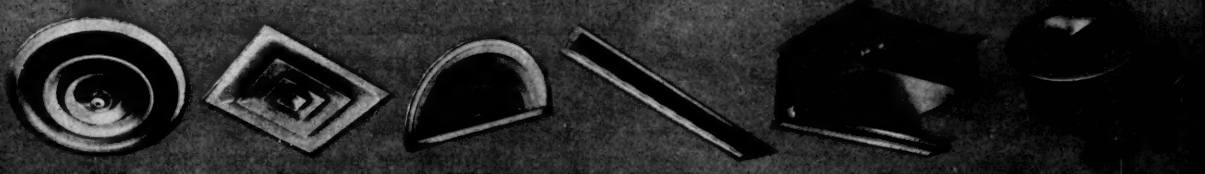
ANEMOSTAT®

DRAFTLESS *Aspirating* AIR DIFFUSERS

ANEMOSTAT CORPORATION OF AMERICA
10 East 39th Street, New York 16, N. Y.
REPRESENTATIVES IN PRINCIPAL CITIES

"No air conditioning system is better than its air distribution"

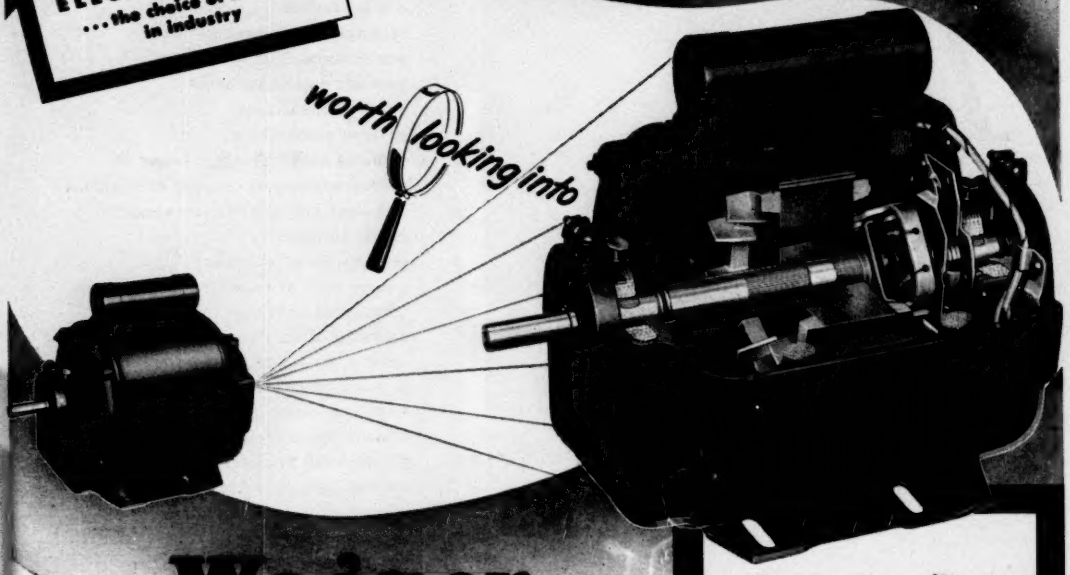
★ ONLY ANEMOSTAT OFFERS ALL THESE TYPES OF AIR DIFFUSERS TO FIT EVERY ARCHITECTURAL AND ENGINEERING NEED



Wagner
ELECTRIC MOTORS
...the choice of leaders in industry

it [illegible] be particular
a[illegible]tors

worth looking into



Wagner
CAPACITOR-START MOTORS

are exceptionally well-adapted to applications with fairly heavy starting loads

The choice of the motor that powers your product is all important. Uniform performance, troublefree long-life operation, a well-known name, and the ability of the manufacturer to provide fast service and repair parts on a nationwide scale, are all factors that add up to satisfied customers for you.

Wagner capacitor-start motors are worth looking into for general purpose applications requiring high starting torque. They are available with sleeve or ball bearings, rigid or resilient bases or a machined end plate for flange mounting. Bulletin MU-185 gives full details—write for your copy.

WAGNER CAPACITOR-START MOTORS...*built in ratings from ⅓ through 3 hp.*

when you choose Wagner Motors you save time, money, worry because:

1. Improved engineering features assure long life and efficient operation.
2. Wagner Motors are available in a wide range of types and sizes for every application.
3. Wagner Motors are backed by a liberal warranty.
4. They are available from Wagner Branches in all principal cities.
5. More than 650 Wagner Authorized Service Stations and Parts Distributors *plus* 25 Wagner-owned Service Branches provide on-the-spot service, replacement motors, or genuine repair parts.

Wagner Electric Corporation
1891 WE 1951

WAGNER ELECTRIC CORPORATION
6463 Plymouth Ave., St. Louis 14, Mo., U.S.A.

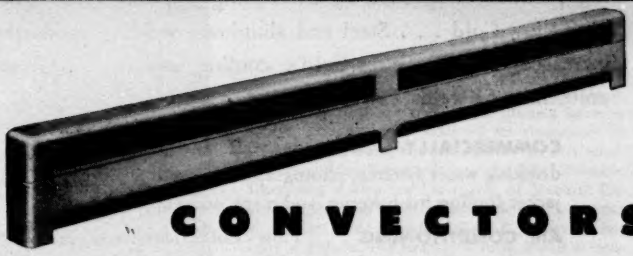
ELECTRIC MOTORS • TRANSFORMERS • INDUSTRIAL BRAKES
AUTOMOTIVE BRAKE SYSTEMS — AIR AND HYDRAULIC

BRANCHES IN 31 PRINCIPAL CITIES

MU51-15

HOW TO ELIMINATE PICTURE WINDOW DRAFTS!

INSTALL YOUNG LOW-LEVEL CONVECTORS



Architects and heating contractors find the Young low-level convector-radiator line ideal for picture window installations. The streamlined, compact cabinets are just 12" high—stand inconspicuously beneath the sill, or hide away in wall recesses. The generous selection of sizes range from 20" to 112" in length, and 4", 6", and 8" in depth— meet any hot water or two-pipe steam system requirement.

What's more, you can rely upon Young ratings. These "FL" models, like the standard line, have been tested and rated in accordance with Commercial Standard CS 140-47, as developed cooperatively by the trade and national Bureau of Standards, U. S. Department of Commerce.

Young low-level models offer many distinctive design features to make specification and installation most satisfactory. The coupon, below, will rush you a copy of our new Catalog No. 4150 just off the press. You'll find it filled with helpful information.

YOUNG

Heat Transfer Products for Automotive and Industrial Applications.

Young Quality

Reg. U. S. Pat. Off.

Heating, Cooling, Air Conditioning Products in Home and Industry.

YOUNG RADIATOR COMPANY

Dept. 521-D, RACINE, WISCONSIN

Plants at Racine, Wisconsin and Mattoon, Illinois

Sales and Engineering Representatives in All Principal Cities

YOUNG RADIATOR COMPANY
Dept. 521-H
RACINE, WISCONSIN

I want to know more about your new low-level convector-radiators. Rush me my copy of Catalog No. 4150, without obligation.

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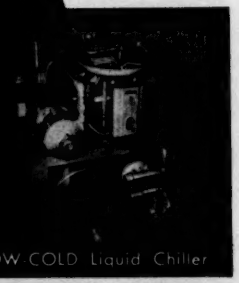
FLOW COLD

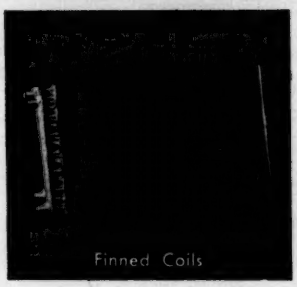


FLOW-COLD Liquid Chiller

FLOW-COLD Cooling Tower

ACME Convector
(Remote Room Air Conditioner)

Suspended Air Handling Unit



Finned Coils

Tremendous production increases reported by industrial firms maintaining temperatures of coolants in broaching, honing, boring, grinding and finishing operations ***with Flow-Cold****. Uniform production and maintenance of closer tolerances result from exact temperature control . . . Plating and anodizing production speeded by controlling solution temperatures with Flow-Cold . . . Steel and aluminum welding production increased through Flow-Cold's cooling action . . . Greater uniformity of welds, fewer rejects.

COMMERCIALLY. . . Here is your answer for central drinking water systems; photographic solution cooling . . . jacket cooling for bakeries, and many other applications.

AIR CONDITIONING . . . Flow-Cold offers you in a compact packaged unit, the ultimate in air conditioning. Home owners, offices, hotels and motels may now enjoy the same *personalized* air conditioning formerly available on large hospital, hotel and office building installations.

Assure your customers a balanced, efficient system with carefully engineered, matching Acme products; Flow-Cold Cooling Towers, Convectors (remote room air conditioners), Finned Coils and Air Handling Units. Over thirty years of experience and top engineering are behind every Acme product. Consult your Flow-Cold wholesaler, Acme's local representative or the factory for further information.

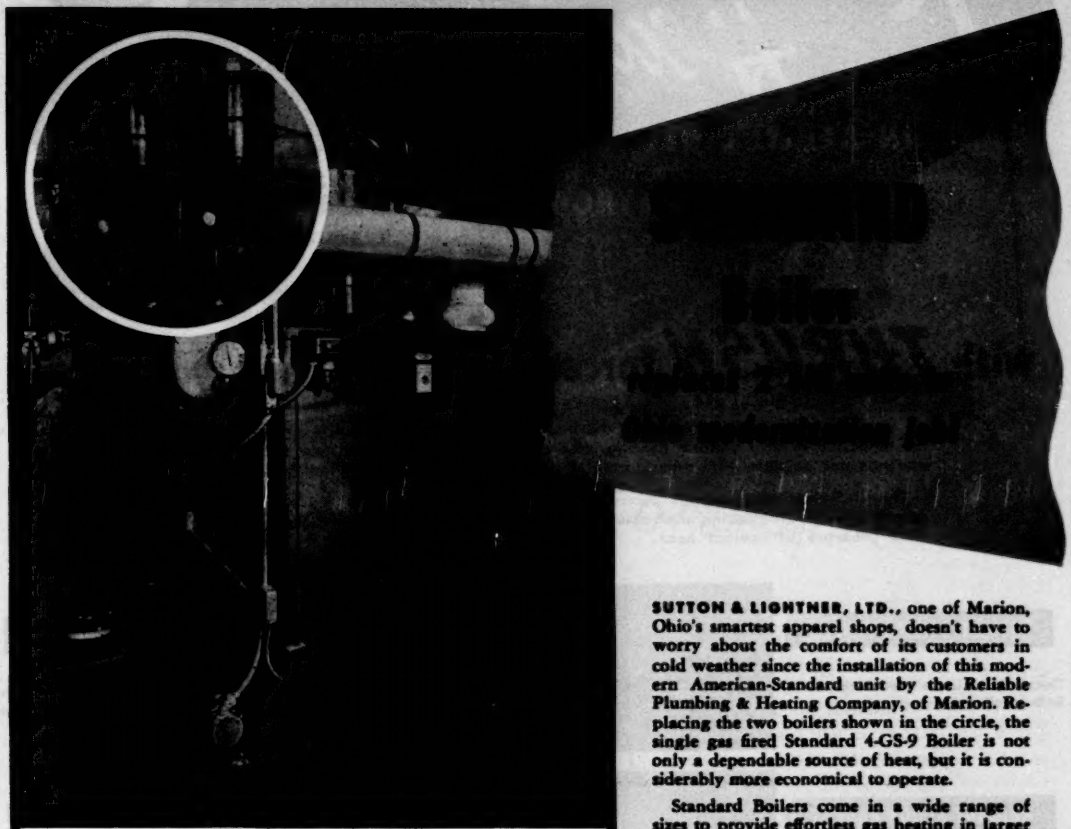
**TRADE MARK*

ACME PRODUCTS

Acme INDUSTRIES, INC.
Dept. HV
JACKSON, MICHIGAN U.S.A.

AMERICAN-Standard

First in heating . . . first in plumbing



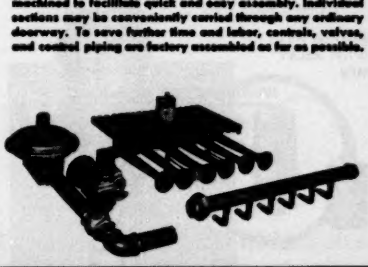
SUTTON & LIGHTNER, LTD., one of Marion, Ohio's smartest apparel shops, doesn't have to worry about the comfort of its customers in cold weather since the installation of this modern American-Standard unit by the Reliable Plumbing & Heating Company, of Marion. Replacing the two boilers shown in the circle, the single gas fired Standard 4-GS-9 Boiler is not only a dependable source of heat, but it is considerably more economical to operate.

Standard Boilers come in a wide range of sizes to provide effortless gas heating in larger homes, apartment buildings, hospitals and various commercial and industrial buildings. They can be used in battery installations in larger buildings to provide an extremely flexible heat source through the operation of one or more units, thus giving greatly increased economy during mild weather, as well as perfect comfort in the coldest weather.

Standard Boilers and other top quality heating equipment by American-Standard are sold through selected wholesale distributors to heating and plumbing contractors. **American Radiator & Standard Sanitary Corporation**, P. O. Box 1226, Pittsburgh 30, Pa.

Precision-machined and sub-assembled to facilitate quick and easy installation

Standard Boilers have cast iron sections which are precision-machined to facilitate quick and easy assembly. Individual sections may be conveniently carried through any ordinary doorway. To save further time and labor, controls, valves, and control piping are factory assembled as far as possible.



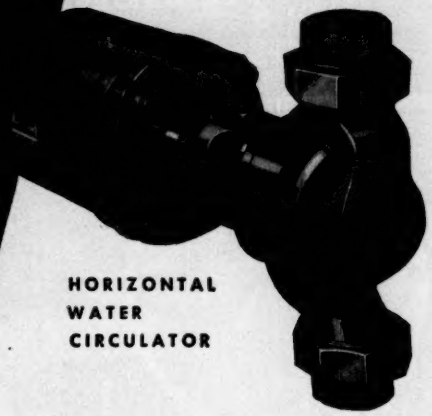
Serving home and industry

AMERICAN-STANDARD · AMERICAN BLOWER · ... · DETROIT LUBRICATOR · ... · KEWANEE BOILER · ... · MANSFIELD · ... · NATIONAL RADIATOR · ...

you can offer your customers

Radiant Heat

IN ALL THE NEW MODERN METHODS



HORIZONTAL WATER CIRCULATOR

with *THRUSH* forced circulating hot water heat

HEATING METHODS are on the march! Forced Circulating Hot Water Heat, which offers the mildest and most uniform heating, also permits the use of many new and modern heating methods not possible with other forms of heating. It is ideal for radiant heating in any form.

Thrush System gives precise control of temperature for hot water heating, completely eliminates wasteful overheating and assures that continuous feeling of well-being due to the constant presence of radiant heat.

RADIANT CEILING PANELS

Thrush Controls are economical, in both installation and operating costs.

RADIANT FLOOR PANELS

Thrush Controls provide continuous warmth with economical Circulator operation.

RADIANT BASEBOARD

Thrush Controls maintain comfort, compensate for outdoor weather changes.

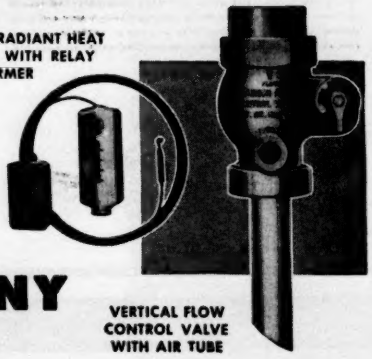
RADIATORS · CONVECTORS

Uniform Heat is always present with Thrush Flow Control System on the job.

ZONE CONTROL

Inexpensive zoning with a Circulator, Flow Valve, and No. 201 Control for each zone.

NO. 201 RADIANT HEAT CONTROL WITH RELAY TRANSFORMER



VERTICAL FLOW CONTROL VALVE WITH AIR TUBE

Ask your wholesaler or write dept. **D-8**

H. A. THRUSH & COMPANY

PERU · INDIANA

Make DOREX AIR RECOVERY part of your air conditioning or heating installation

Every ventilation system must supply a certain amount of fresh air to maintain satisfactory air quality within the conditioned space. But air supplied from the outside must be heated or cooled, depending upon the season. Dorex Air Recovery reduces the amount of outside air required for ventilation . . . thus, substantially less heating and cooling equipment is needed, and critical materials are saved.

The thrifty Dorex C Cell is a simple device that "manufactures" *fresh* air from *used* air by passing it through activated carbon – reducing, by as much as two-thirds, the amount of outside air that has to be taken into the system.

In dollar savings, this means that every $100 invested in Dorex Air Recovery should save some $400 on original heating and cooling equipment . . . and, in operation, every $1 spent for Dorex maintenance should return a $4 saving in running costs. These are averages based on 20 years' experience and over 7,000 Dorex installations.

Let us show you in detail the dollars-and-sense value – to you and your customers – of Dorex Air Recovery. Mail the coupon today.

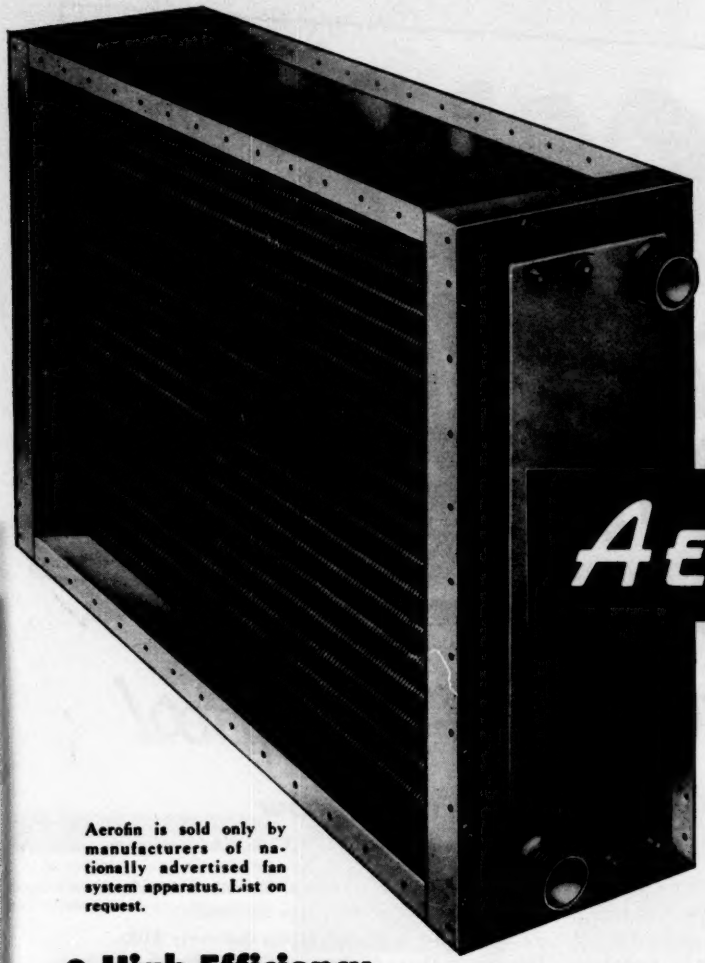
TRADE MARK "DOREX" REG. U. S. PAT. OFF.

DOREX
Air Recovery

W. B. CONNOR ENGINEERING CORP.
Danbury, Connecticut
Air Diffusion • Air Purification • Air Recovery
In Canada: Douglas Engineering Co., Ltd.,
190 Murray Street, Montreal 3, P. Q.

W. B. CONNOR ENGINEERING CORP.
Dept. B-8, Danbury, Connecticut
Please send me, without obligation, full information on Dorex Air Recovery.

Name .....
Position .....
Company .....
Street .....
City ..... Zone ..... State .....



AEROFIN

Heat-Transfer Surface

Aerofin is sold only by manufacturers of nationally advertised fan system apparatus. List on request.

● High Efficiency
● Long Service Life
● Low Maintenance Costs

You are assured of high efficiency in heating or cooling — long service life — low maintenance and service costs, when you specify Aerofin extended-surface heat exchangers.

The reason is obvious: Aerofin makes heat exchangers *exclusively* — offers you the results of unequalled experience, unequalled production facilities, unequalled materials testing and design research — and the guidance of a complete, highly skilled engineering staff, at the plant and in the field.

For the most practical solution to your heat-exchange problem, ASK THE AEROFIN MAN.

AEROFIN CORPORATION
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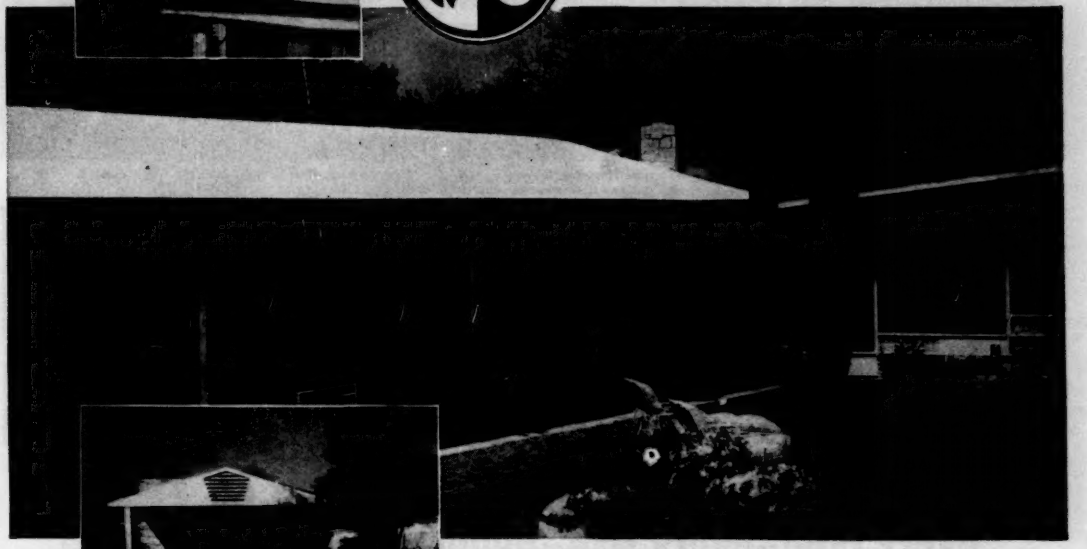
NEW YORK • BOSTON • CHICAGO • CLEVELAND • DETROIT • PHILADELPHIA • DALLAS
SAN FRANCISCO • MONTREAL • TORONTO

"House of Ideas"

Sponsored by House & Garden

Selects

Hydro-Flo Heating



Zoned for better heat control

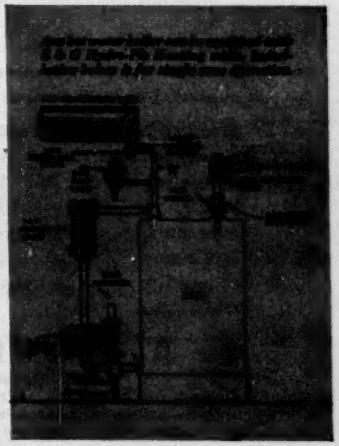
The heating system of the "House of Ideas" is divided into three zones, individually controlled by the B & G *Hydro-Flo* Booster Pumps illustrated above. Zoning provides compensation for varying exposures and, if desired, permits different temperatures in different parts of the house.

In the "House of Ideas", sponsored by HOUSE & GARDEN, beauty and convenience are fully supplemented by winter comfort. A *completely concealed* B & G *Hydro-Flo* Radiant Panel Heating System distributes radiant sunny warmth throughout.

B & G *Hydro-Flo* Heating is a *forced hot water system* . . . which means that the heat supply is always under positive control. The temperature of the water circulating through the system is automatically raised or lowered to meet every change in the weather. Even in spring and fall, when only a little warmth is needed, indoor temperature is kept exactly at the comfort level—no wasteful overheating.

That's why a B & G *Hydro-Flo* Heating System costs so little to operate—it matches fuel consumption to weather conditions. This ultra-modern system permits a choice of *baseboard panels, convectors, radiators or radiant panels.*

B & G *Hydro-Flo* Heating adds plus value to any home—increases saleability. Send for free booklet, "Capture the Sun with B & G *Hydro-Flo* Heating."



BELL & GOSSETT

C O M P A N Y

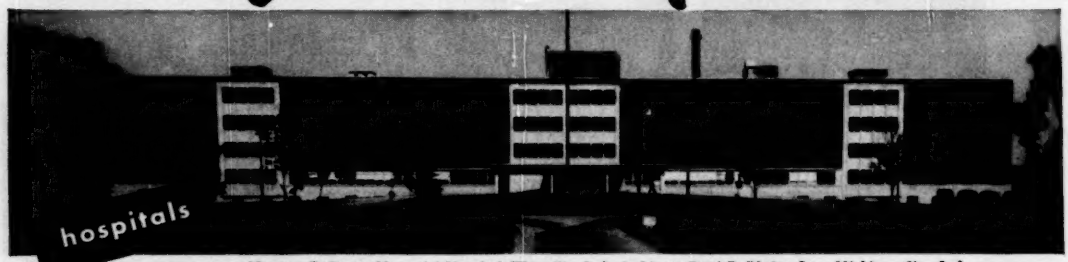
Dept. CD-4, Morton Grove, Ill.

Canadian Licensee: S. A. Armstrong, Ltd., 1400 O'Connor Drive, Toronto, Canada •Reg. U. S. Pat. Off.

DUNHAM

vari-vac differential heating

Cuts fuel costs up to 40%



Norman F. Beatty Memorial Hospital, Westville, Ind. Architect: Boyd E. Phelps, Inc., Michigan City, Ind. Heating Contractor: Robert Gordon Co., Chicago, Ill.

St. Thomas High School, Houston, Tex. Architect & Consulting Engineer: Maurice J. Sullivan, Houston, Tex.

provides precision temperature control for every type–every size–building

Substantial Savings in Fuel Costs are assured with Dunham Vari-Vac* Differential Heating Systems. That's because outside weather and inside temperatures automatically control steam consumption. No more steam is ever used than is necessary.

Dunham Vari-Vac economizes with a "continuous" flow of sub-atmospheric steam at variable pressures and temperatures. In severe weather, Vari-Vac uses steam as "hot" as 218° F. In mild weather, smaller quantities of steam as "cool" as 135° F. are expanded to meet comfort needs.

Sized to Suit Your Needs . . . in New or Existing Buildings. Seven different systems are available, depending on the degree of control desired. Whichever system you install — whether a simple, manually operated Basic Job or a fully automatic Supreme Installation — your customer is sure to enjoy maximum fuel economy and comfort . . . regardless of the size, type, age or location of his building.

**Variable Vacuum*

Instantaneous response to outside weather changes.

Convenience of centralized operation.

Automatic Compensation for heat loss.

Heat supply and demand perfectly balanced.

Send for Free Booklet 2101-16. Tells all you will need know about this amazing system—how it operates, how it may be fitted exactly to your customers' needs. Write for your copy.

C. A. DUNHAM COMPANY

400 W. Madison Street, Chicago 6, Illinois

In Canada: C. A. Dunham Co., Ltd., Toronto • *In England:* C. A. Dunham Co., Ltd., London

Fin-Vector Radiation • Baseboard Radiation • Convector Radiation • Vacuum Pumps Condensation Pumps • Horizontal and Vertical Discharge Heaters • Traps • Valves

SEND FOR THE NEW P-K 40 PAGE WATER HEATER CATALOG

p-k catalog No. 202 provides you with a simple, rapid means of selecting the correct hot water heater for forced circulation.
Capacities from 95 to 101,000 gph.
Steam pressures range from 0 to 100 psig.
Standard "U" Tube Heaters are available in 2- 4- or 6-pass construction.
Water temperatures range from 40° to 100°F. inlet and 80° to 300°F. outlet.

1035

other TAB INDEX FEATURES

- Condensate Cooler tables
- Dishwater Booster Heater tables
- Gravity circulation tables
- Hot Water Service Heater tables
- Pressure drop tables
- Typical piping arrangement

the P-K please send p-k catalog 202

Patterson-Kelley Co., INC.

88 BURSON ST., EAST STROUDSBURG, PENNA.

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Company _____

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. . . with a background of twenty years

1931

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PHOTO BY EZRA STOLLER
THE AUSTIN COMPANY, ENGINEERS AND BUILDERS

For over 20 years The Upjohn Company, Kalamazoo, Michigan has been a continuous user of ILLINOIS Automatic Steam and Fluid Control Equipment as an integral part of its air conditioning and vacuum heating systems and process control.

ILLINOIS Specialties meet fully the exacting requirements of this, "The World's Largest Industrial Air Conditioning Project".

120 separate air conditioning systems in this new unit handle 2,800,000 cfm.

Western Michigan Representative: **Marshall & Wells Company, Grand Rapids**

ILLINOIS ENGINEERING COMPANY
INCORPORATED 1900
RACINE AVENUE AT 21ST STREET • CHICAGO 8

PRODUCE MORE WITH YARWAYS...

Is higher production your aim?

Then Yarway is your steam trap. Best steam trap performance requires condensate drainage *plus*—

1. Air and gas removal.
2. Velocity scrubbing of condensate from heat transfer surfaces.
3. Keeping highest average temperature in the equipment.

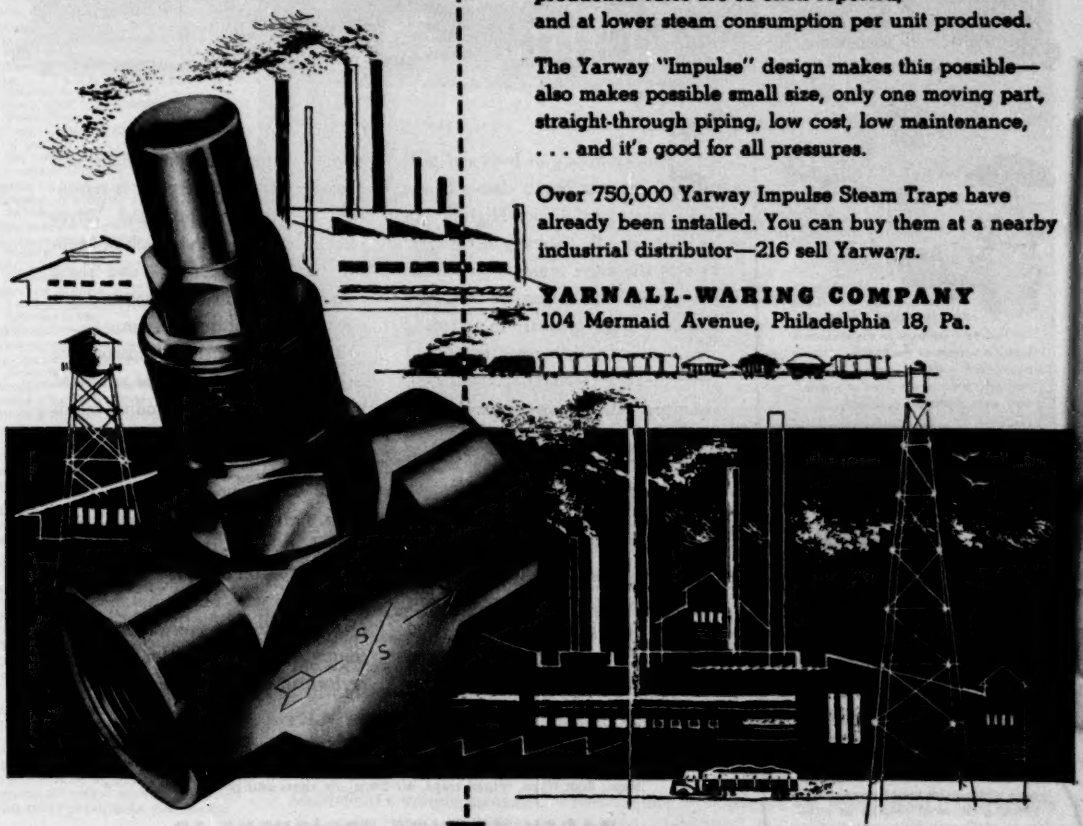
Yarway Impulse Steam Traps do all this, *sending the most premium B.T.U.'s at top temperature into your process or product.*

That's why equipment drained with Yarways gets "hotter, sooner" . . . why better quality and higher production rates are so often reported, and at lower steam consumption per unit produced.

The Yarway "Impulse" design makes this possible—also makes possible small size, only one moving part, straight-through piping, low cost, low maintenance, . . . and it's good for all pressures.

Over 750,000 Yarway Impulse Steam Traps have already been installed. You can buy them at a nearby industrial distributor—216 sell Yarways.

YARNALL-WARING COMPANY
104 Mermaid Avenue, Philadelphia 18, Pa.

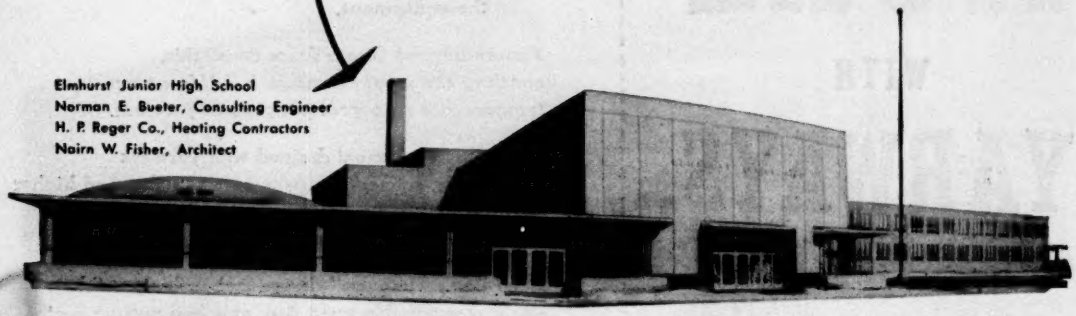


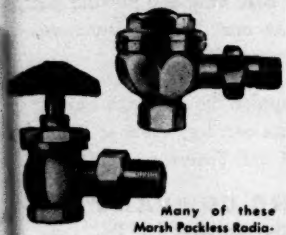
FREE OFFER
Don't take our word for it. Test Yarway's production advantages in your own plant, without cost or obligation. Drop us a card. A trial trap will be delivered promptly.

YARWAY the steam trap designed with production in mind

What equipment but MARSH ...for a model school building like this?

Elmhurst Junior High School
Norman E. Bueter, Consulting Engineer
H. P. Reger Co., Heating Contractors
Nairn W. Fisher, Architect





Many of these Marsh Packless Radiator Valves were used in the elaborate heating system of the Elmhurst Junior High, and a large number of thermostatic traps were used in connection with radiators and coils.

The Marsh No. 8 float and thermostatic trap, illustrated, is typical of many traps of this kind used in the Elmhurst school.

BIG SAVINGS WITH MARSH—TRITROL—heat regulation in step with the weather

By controlling inside heat in accordance with outside temperature, Marsh Tritrol gives ideal comfort at minimum cost. Installation is simple. Cost remarkably low. Ask for Bulletin S-750.

A lucky throng of boys and girls have just begun classes in the newly completed Junior High School at Elmhurst, Ill., a suburb of Chicago. One of the finest junior high schools ever built, the expansive structure houses a large gymnasium, a totally separate auditorium seating 900, a large, pleasant cafeteria, spacious well-equipped classrooms—facilities far beyond those of the old-time schools their dads and mothers knew as full fledged high schools.

In the rapid advance of school buildings during recent years, no phase has seen greater improvement than heating and air conditioning, and this model school is a particularly good example of this. No expense has been spared in any detail of the vacuum system to make it functionally and permanently effective. So it is significant that Marsh Traps and Valves were chosen for the vital job of keeping heating coils, mains and risers free from air and condensate throughout the entire heating system.

The use of Marsh equipment here is just one more example of advanced heating systems in outstanding buildings all over America in which Marsh heating equipment has been the first choice of foremost consulting engineers, heating contractors and architects. Use Marsh traps, valves, vents, and controls on that next job and you will know why Marsh has been so often accorded top preference for uncompromising quality, for consistent performance, for downright *value.*

Ask for new Catalog 76-H covering Marsh packless valves, radiator traps, float and thermostatic traps, inverted bucket traps, float traps, return traps, air traps, air vents and boiler gauges.

MARSH HEATING EQUIPMENT CO.

Sales affiliate of Jas. P. Marsh Corporation • **Dept. U, Skokie, Ill.**

MARSH *Heating Specialties*
SINCE 1865

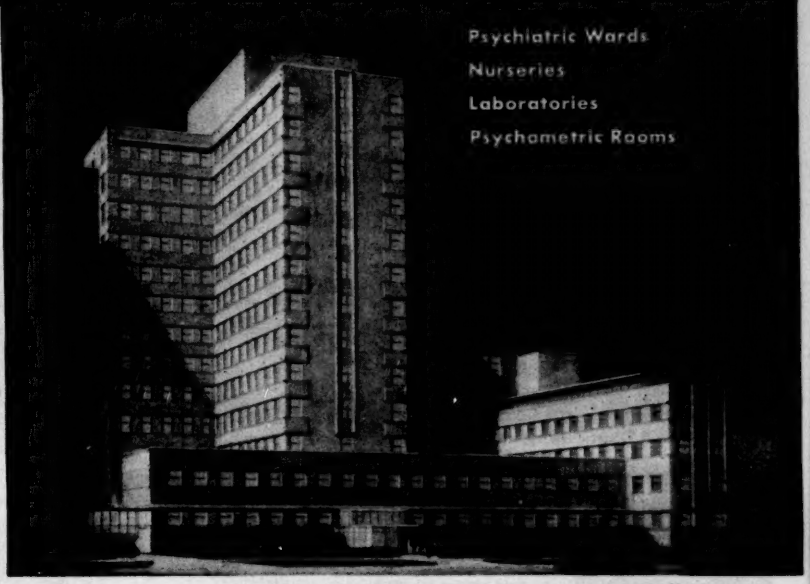
MULTI-VENT

...ow Velocity Air Diffusion CEILING PANELS

Operating Rooms
Environment Control Rooms
Delivery Rooms

solve the *really tough* Air Distribution problems in hospitals

Psychiatric Wards
Nurseries
Laboratories
Psychometric Rooms



Multi-Vent Ceiling Panels have been specified for the new addition to the UNIVERSITY OF ILLINOIS RESEARCH AND EDUCATIONAL HOSPITALS, Chicago
Architects • Holabird, Root & Burgee, Chicago
Consulting Engineers • E.P. Heckel & Assoc., Chicago

Recent MULTI-VENT Installations

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CHICAGO LYING-IN HOSPITAL, Chicago, Illinois
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ST. VINCENT'S HOSPITAL, Santa Fe, New Mexico
SAMARITAN HOSPITAL, Ashland, Ohio
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ROSE MEMORIAL HOSPITAL, Denver, Colorado
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BEAR LAKE MEMORIAL HOSPITAL, Montpelier, Idaho
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ANOKA T. B. STATE HOSPITAL, Anoka, Minnesota
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STATE OF WISCONSIN—GENERAL HOSPITAL, University of Wisconsin
ST. JOSEPH'S HOSPITAL, Hancock, Michigan
IVINSON HOSPITAL, Laramie, Wyoming
BYBERRY STATE HOSPITAL, Tubercular Patients Building N-10
NEW MOUND PARK HOSPITAL, St. Petersburg, Florida
HEART HOSPITAL, University of Minn., Minneapolis, Minn.
JUAB COUNTY HOSPITAL, Nephi, Utah
SOMERSET STATE HOSPITAL, Somerset, Penn.
GILLETTE HOSPITAL, St. Paul, Minnesota
GADSDEN COUNTY HOSPITAL, Quincy, Florida
UNIVERSITY OF ILLINOIS, PHYSICAL ENVIRONMENT LABORATORY Urbana, Illinois
CHESTNUT HILL HOSPITAL, Philadelphia, Pa.
UNIVERSITY OF CALIFORNIA, Medical School—Teaching Hospital
PASTEUR MEDICAL BUILDING, Oklahoma City, Okla.
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✻ See SWEET'S Arch. & Eng. Files or: Write for detailed literature and the name of the Multi-Vent sales engineer in your vicinity.

Hospital medical staffs and technicians are rapidly recognizing that the Multi-Vent panel is *the* one air diffuser that can surely meet, even surpass, their rigid air distribution requirements for air conditioning these critical hospital areas.

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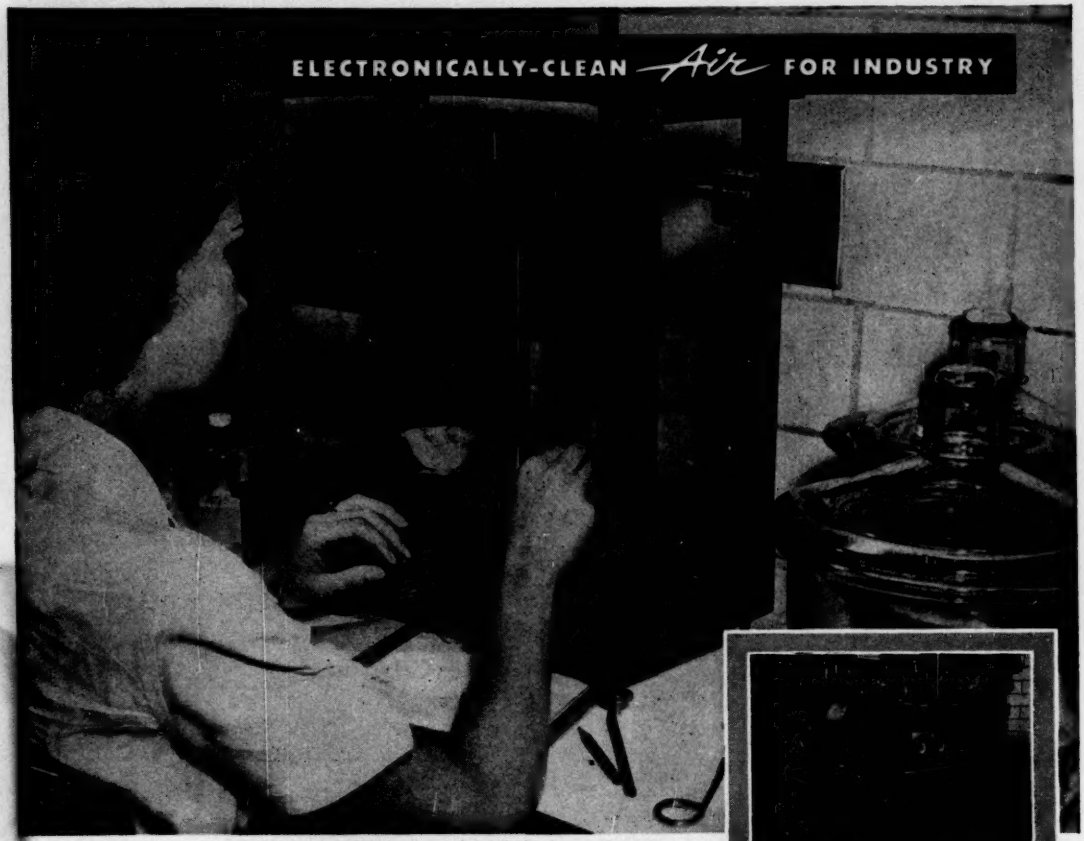
ELECTRONICALLY-CLEAN *Air* FOR INDUSTRY



M & R Dietetic testing lab, where clean, conditioned air plays a vital role.

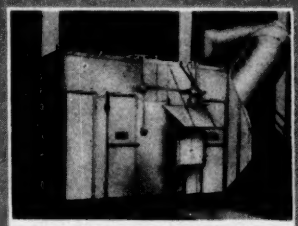
HOW SUPER-CLEAN AIR GUARDS QUALITY AND PRODUCTION

Manufacture of baby foods requires exceptional standards of cleanliness. Every vessel must be sterile—and the air itself pure. M & R Dietetic Laboratories, makers of CEREVIM baby cereal and SIMILAC powdered infant food, insisted on *really clean* air. So PRECIPITRON®—the *electronic* air cleaner—was installed. Now they remove harmful contaminants so small that they can be seen only with the finest Ultra Microscope.

PRECIPITRON also increases production. In one separating process, 20% of the dried milk was once discarded because air-borne contaminants passed through mechanical air filters. Now 100% is useable, and is better graded too. In the testing lab, precisely-controlled humidity and temperature help improve product uniformity and increase the efficiency of the technical staff.

There's a complete line of Westinghouse equipment to help you *put air to work*—with electronic air cleaning, air handling, or air conditioning. Contact your local Westinghouse-Sturtevant office, or write Westinghouse Electric Corporation, Sturtevant Division, Hyde Park, Boston 36, Massachusetts.

Westinghouse Hermetically-Sealed air conditioning compressors can be installed in an unventilated space.



PRECIPITRON stops dirt *before* it enters the building. Its efficiency is triple the best mechanical cleaner.

There's nothing to remove from PRECIPITRON but dirt. It's periodically washed down drain with a water hose.

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FROM 20,300 to 360,000 BTU!

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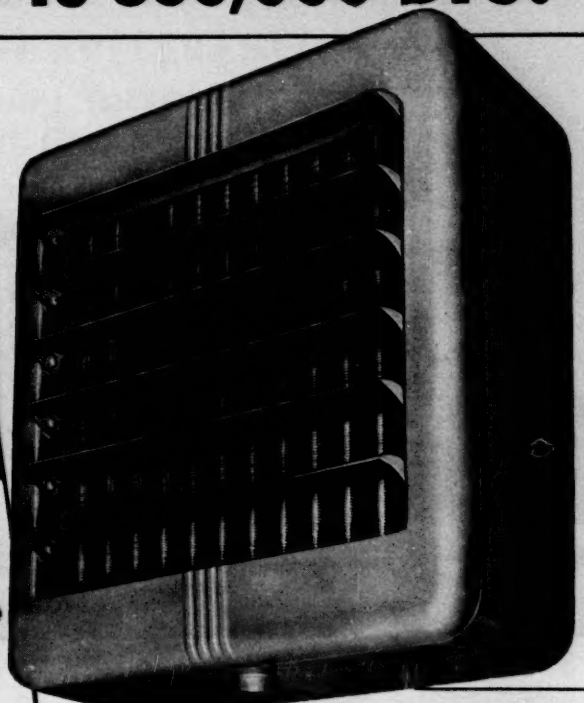
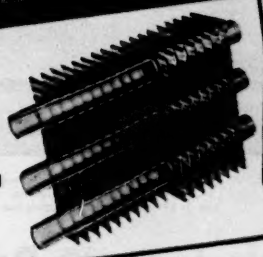


McQuay HORIZONTAL UNIT HEATERS

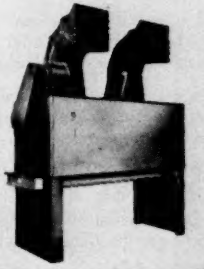
ANOTHER RIPPLE FIN COIL APPLICATION



Within the wide range of BTU capacities, you're sure to find McQuay Horizontal Unit Heaters to fit your needs. Every unit has the exclusive Ripple Fin Coil construction . . . with these advantages: more heat transfer surface, greater flexible strength, cleaner operation . . . flexible copper tube headers that accommodate unequal expansion and contraction. Tubes expanded into fins having wide, smooth collars, without the use of any low conductivity bonding agents, provide a permanent mechanical bond. The famous Ripple Fin Coil plus modern cabinet styling, quiet motor fan assembly and Test Code Ratings add up to maximum performance and trouble-free service. Get all the facts from the McQuay representative in your city; or write to McQuay, Inc., 1619 Broadway St. N.E., Minneapolis 13, Minn.

DOWN FLOW UNIT HEATERS

This McQuay "vertical" unit heater, suspended near the ceiling, utilizes the warm air in that area and distributes it down to the floor level. No wasted heat, no cold spots. Four types of draftless diffusers available.

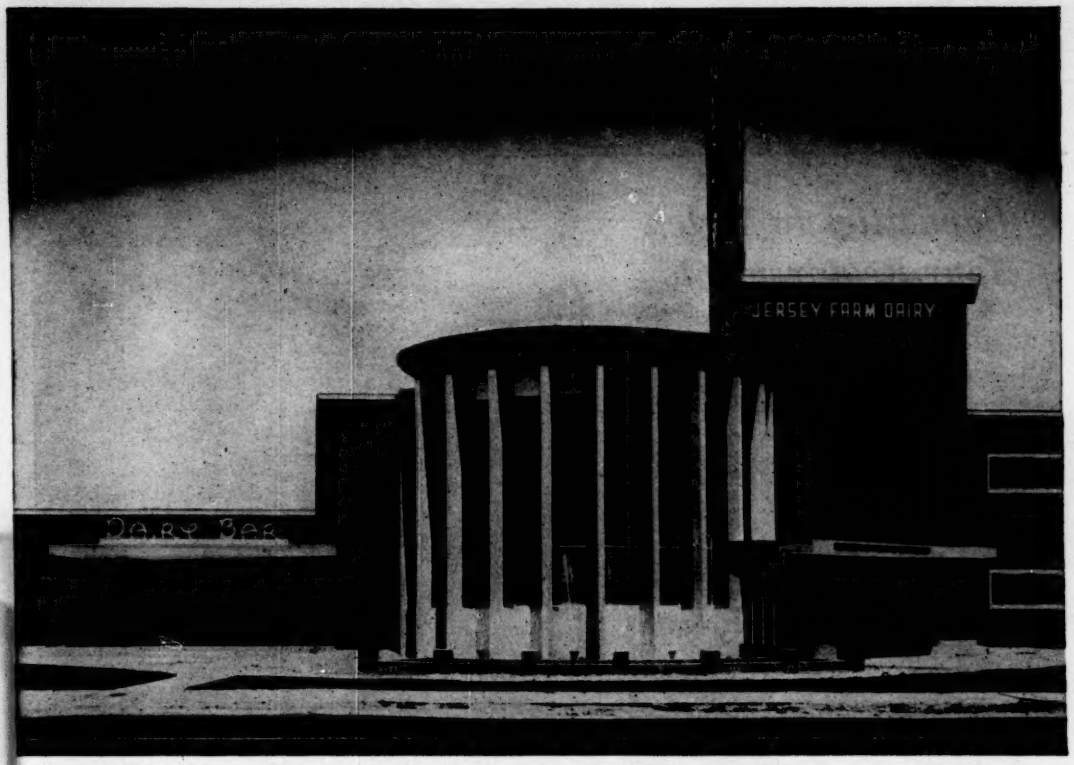


BLOWER TYPE UNIT HEATERS

For effective heat distribution over large open areas. Available in 8 sizes . . . in suspended and floor models, with one and two row coils; capacities from 23,800 to 1,659,000 BTU per hour.

McQuay INC.

HEATING • AIR CONDITIONING • REFRIGERATION



Architect: Robert Fitch Smith & Associates, Consulting engineer: Maurice H. Connell & Associates, Inc., Refrigeration contractor, Dade Refrigerating Co., Inc., all of Miami.

Marlo Serves the "Nation's Largest Dairy"*

McArthur Dairy in Miami, Florida selects Marlo Evaporative Condenser for Ultra Modern Plant

Engineered to serve better—and last longer—modern Marlo cooling units offer these important advantages to *every* installation:

- Top Efficiency—they save up to 95% of normal cooling water demand through effective recycle cooling.
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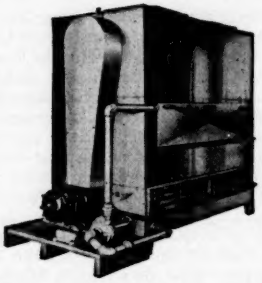
- Out-of-Sight Installation—Compact, all-metal Marlo units are installed indoors or on roofs below the parapet, never mar building beauty.
- Durable—with exclusive four-way protection against corrosion—inside and outside.



Marlo Evaporative Condenser

Write for information on the modern Marlo line.

*●MIAMI *NEWS

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COOLING TOWERS • EVAPORATIVE CONDENSERS • INDUSTRIAL COOLERS
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are determining factors
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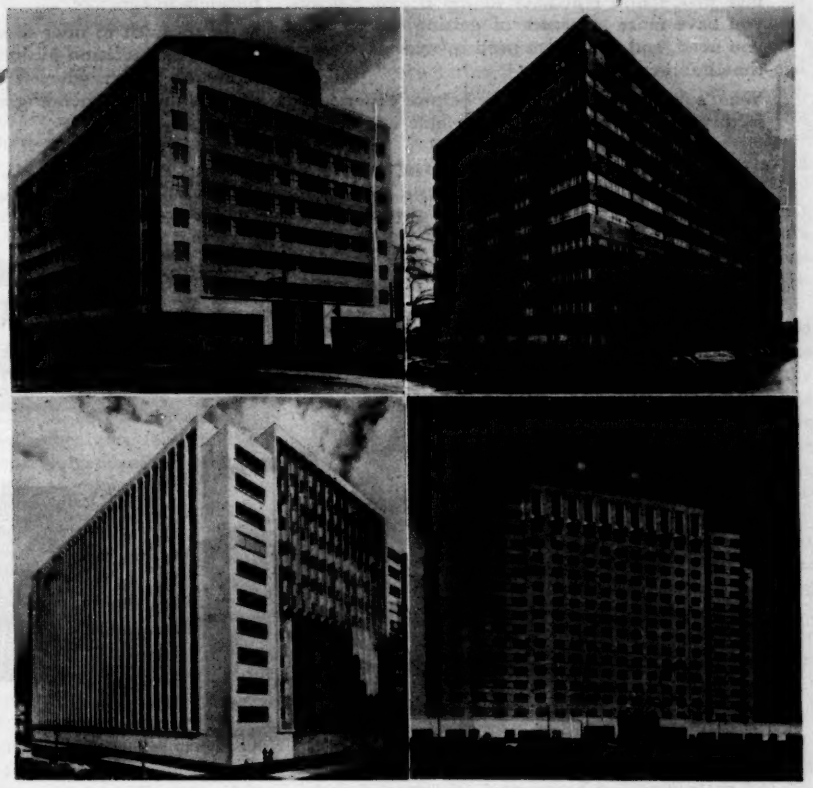


• Right, California Building, New Orleans, La. Architects, Herbert A. Benson and George J. Riehl; Engineer, Cary B. Gamble and Associates; General Contractor, Keller Construction Co.; Mechanical Contractor, Emile M. Babst Co. — all of New Orleans.

• Far right, Allstate Insurance Company Building, Chicago, Illinois. Architects, Carr and Wright, Inc.; Consulting Engineer, Robert E. Hattis; Heating Contractor, Gallaher and Speck, Inc.; Ventilating Contractor, Acord Ventilating Co. — all of Chicago.

• Right, General Petroleum Office Building, Los Angeles, California. Architect, Wurdeman & Becket; Mechanical Engineer, Ralph E. Phillips; Air Conditioning Contracting Engineers, W. S. Kilpatrick Co. — all of Los Angeles.

• Far right, Shamrock Hotel, Houston, Texas. Architects and Engineers, Wyatt C. Hedrick, Inc.; Mechanical Contractors, Associated Mechanical Contractors, Inc. — all of Houston.

BARBER COLMAN

BARBER-COLMAN COMPANY

1224 ROCK STREET, ROCKFORD, ILLINOIS

BRUNNER SINCE 1906 **REFRIGERATION** helps you serve better

Maybe we can help if you are having trouble finding the units you need!

With 69 different models, types and capacities of refrigeration condensing units being built on regular production schedules in the Brunner plants, you have more assurance of getting exactly what you need, and when you need it, without wasting time hunting.

What's more, we offer you the help of experienced factory field men backed by an able engineering staff who have encountered and answered just about every kind of refrigeration or air conditioning problem imaginable.

With so much to offer folks engaged in the commercial refrigeration business, it just doesn't make sense to deprive yourself of the advantages that come with recommending and installing Brunner's as a regular habit.

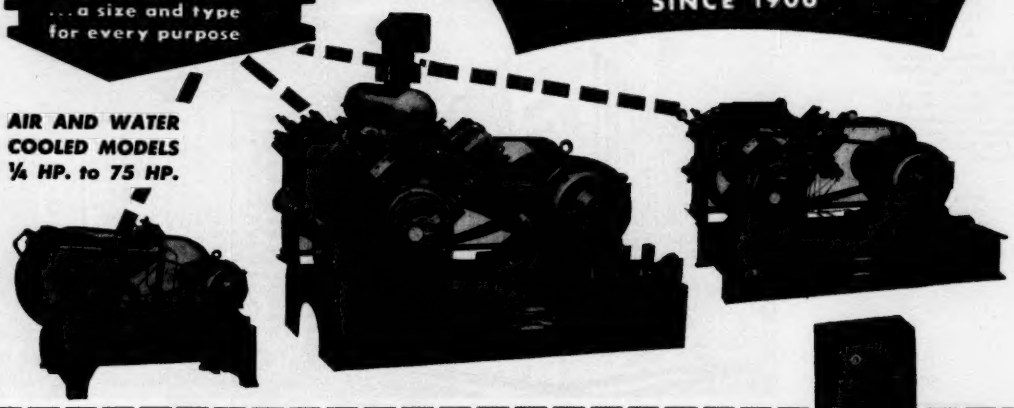
BRUNNER MANUFACTURING COMPANY, UTICA 1, N. Y., U. S. A.

P.S. *As a business man you should talk to a Brunner factory sales engineer. It costs nothing to listen, and you may discover that you have been missing a good bet. Your name and address written on the margin of this ad and mailed to us at Utica is all that is necessary.*

REFRIGERATION CONDENSING UNITS ...a size and type for every purpose

BRUNNER SINCE 1906

AIR AND WATER COOLED MODELS ¼ HP. to 75 HP.



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AIR CONDITIONING

Self Contained Units in 4 sizes: 3-5-7½ and 10 HP.
Remote Installation Types from 3 to 75 HP.

Washington News

LORING F. OVERMAN

HEATING, ventilating and air conditioning people —as producers, users and installers of the so-called "B" products of Washington's Controlled Materials Plan—will be particularly interested in at least two of many recent developments in the Nation's capital.

First item is the forecast that the 1951 building total is headed for a record high of $29.2 billion volume.

Second is the likelihood that the Controlled Materials Plan will be changed into a closed-end affair.

Put those two together and we find (1) that the building outlook for the year offers H & V folks a physical volume market only slightly below last year, and (2) that a closed-end CMP plan would allocate to participating industries the materials needed to carry out the program. Thus, if NPA is to approve $29.2 billion in construction involving a certain proportion of heating, ventilating and air conditioning installations, it is presumed to have in its materials bank enough units to complete the program authorized.

The Building Outlook

Attainment of the $29.2 billion mark estimated for 1951 would raise expenditures above those of any previous year for the fifth consecutive time. Prior to 1950, 1926 and 1927 had been the most active building years. In terms of 1950 costs, building during each of those years totalled $25.2 billion. Not again until 1950 did they reach that level.

Big increases are anticipated in expenditures for privately financed industrial, educational, hospital, institutional and miscellaneous nonresidential building. Publicly financed construction to gain will include industrial, educational, institutional, hospitals and military and naval construction.

Reduced spending is in sight for private residences, social and recreational types, and an "all other" classification which includes privately owned water and sewer systems, bridges, roads, stadiums, swimming pools, parks and playgrounds.

Industrial construction—of great interest to H & V readers—is expected to total almost twice the $1,062 million reported in 1950. The rush is on to build enough capacity to produce steel, aluminum, chemicals and other goods for both defense and civilian needs.

Commercial construction began in May to show effects of the building ban included in NPA Order M-4. A marked decline in the rate of spending for commercial types of construction is expected during the balance of the year. The head start received during early months of the year is expected to keep the total up to the $600 million annual rate established last year.

Educational building, privately financed, as well as hospitals and institutions, are considerably ahead of 1950 levels. They show no signs of leveling off. Church building, continuing an advance which began in 1943, seems headed for a third straight record. Expenditures for 1951 are projected 17% ahead of 1950, at $480 million.

CMP Outlook

As reported last month, controls spawn controls, and it still seems likely that the Controlled Materials Plan will be expanded to include all manufacturing operations. NPA is pondering the matter and should make its decision by mid-August. Closing up of the CMP would mean the making of allotments of controlled materials to all producers of "B" products. Operating under a closed CMP, manufacturers of consumer durable goods would receive authorized production schedules, allotments, and DO ratings to purchase noncontrolled materials and other "B" products required for the completion of authorized production schedules.

For example, if a manufacturer were authorized to produce 1,000 unit heaters, he would receive authority to buy the necessary steel, copper and aluminum, as well as 1,000 electric motors or other "B" products needed to complete the heaters.

Experience during World War II was that there just wasn't enough of everything to go around. As a result, the War Production Board issued limitation orders banning the manufacture of long lists of consumer goods designated as nonessential. WPB also issued tight controls covering basic chemicals and many secondary metals. Current indications are that scarcity of some chemicals and secondary metals would again plague those not in direct support of defense production, and that additional controls would follow the closing of CMP.

In any event, CMP is to take over the distribution of controlled materials for construction projects. The CMP construction order (CMP Reg 6) was originally permissive in form, but the situation has changed. The regulation will now be used both for authorization to start construction of all building requiring more than very minimum amounts of steel, copper and aluminum.

At month-end, Washington was awaiting the revocation of NPA Order M-4 (the original building order). In its place was expected a new conservation order prescribing the limited amounts of building materials that can be used for specified purposes, without applying to NPA for permission to go ahead. In preparation for the changeover, those who have filed applications on Form NPA-F24 have been asked to file a new form CMP-4C.

Fuels Eyed

So far, both oil and natural gas show signs of developing shortages. A survey of coal production facilities is under way, with no inkling as to whether ample supplies may be anticipated. Secretary of the Interior Chapman, testifying in mid-July before the Senate Interior Committee, warned that rationing of petroleum products and restriction of the use of gas is in

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(4 to 1, we'll save you money)

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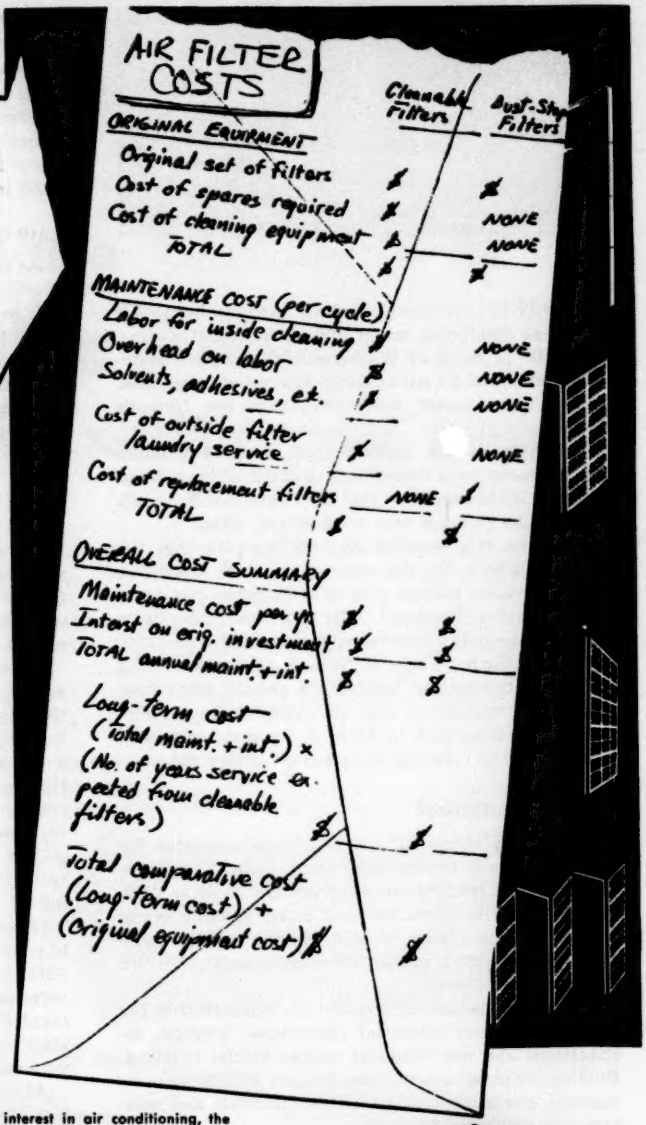
Why? Because while rising labor costs have made filter cleaning more expensive, mass production has lowered the cost of Dust-Stop filters. In fact, on the basis of one 40c cleaning every 90 days, cleanable filters would have to last up to 14 years to match the cost of Dust-Stop Filters replaced at the same intervals . . . and you get a *new* filter with each change.

Check the facts: The "Comparative Study" shown below will help you. Send for it today. Owens-Corning Fiberglas Corp., Dept. 41-H, Toledo 1, Ohio.



Whatever your interest in air conditioning, the facts, figures and charts in this study are important to you. Write for your free copy today.

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DUST STOP* AIR FILTERS

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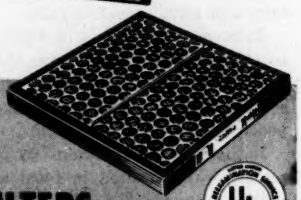

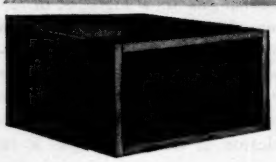

FIBERGLAS INSULATION FOR AIR DUCTS

Ageless, light in weight, firesafe, moisture resistant, Fiberglas Duct Insulations can be quickly applied . . . have very high acoustical value . . . won't erode at 6,000 fpm . . . cost less than other insulations approaching them in thermal efficiency. Write for details.

*DUST-STOP is the trade-mark of Owens-Corning Fiberglas Corporation for impingement-type air filters made of glass fibers. FIBERGLAS is the trade-mark (Reg. U. S. Pat. Off.) of Owens-Corning Fiberglas Corporation for a variety of products made of or with fibers of glass.

prospect unless the industries receive additional steel for development work during the fourth quarter of this year.

Rationing "six or eight months from now" was the grim forecast by Secretary Chapman unless the oil and gas industries receive adequate allocations of steel from CMP. He fixed the needs of the industries at 2,385,000 tons for the third quarter and 2,135,000 for the fourth. NPA allocated 1,583,000 for the third quarter of 1951, and is considering 1,862,000 for the fourth. Making a strong plea for more steel, the Secretary said the situation "is a simple illustration of cause and effect. No steel, no gas. I trust that I can be forgiven for remarking that unless the oil people can be supplied with the steel they need, it is only a question of time before there will be a new wave of protest from automobile owners and homeowners heating with oil."

Uncertainty over the situation in Iran was another factor causing concern, as was also the likelihood that petroleum requirements will increase during the next 12 months by even more than 11% recorded during the year ended April 1, 1951. Mr. Chapman estimated that crude oil production from new fields and increased product demands will require about 740,000 tons of steel for new trunk lines, in 1951 and 1952, not counting about 116,000 tons to extend existing lines.

For natural gas, Mr. Chapman said, about 515,000 tons of pipe for transmission and distribution lines was allocated during the third quarter, providing nothing for new projects. If his agency is allotted the full amount requested for the fourth quarter, gas transmission lines should receive about 420,850 tons and distribution lines about 140,000.

Despite the need for a gas line to the Pacific Northwest and for additional gas lines into New England, these cannot be recognized, he said.

He also explained that basic capacity to produce refined petroleum products in refineries and natural gas plants must be expanded by one million barrels a day before the end of 1953. Only enough steel is available for the refinery construction program, he said.

Several members of the Senate Committee expressed surprise that, in view of expanded steel capacity, additional steel was not assigned to the petroleum industry. They were told that although production of steel is now estimated at a rate of 108 million tons per year, capacity for making pipe is limited. Conversion of some strip rolling mills to the production of heavier plate would help remedy the situation, they were told.

4 Uniform Standards

Offsetting somewhat the gloomy reports from oil and gas fields is the information that four uniform standards have been approved for federal building projects. The standards, which are the present national standards for structural steel, reinforced concrete, stress-grade lumber and plumbing installations, were endorsed by a newly formed subcommittee of DPA's Conservation Coordinating Committee to conserve critical materials in new federal building projects.

The subcommittee said it is hoped that the uniform construction and plumbing practices will be observed by both government agencies and all segments of the construction industry. Widespread recognition of the standards might conserve enough scarce materials to permit an increase in amounts permitted other civilian projects, DPA officials said. The subcommittee is composed of engineers, specification writers and other technicians from the following government agencies: National Production Authority, Facilities and Construction Bureau; Department of the Army, Corps of Engineers; Department of the Navy, Bureau of Yards and Docks; Department of the Air Forces; Defense Establishments, Munitions Board; Veterans Administration; General Services Administration; Federal Security Agency; Housing and Home Financing Agency; National Bureau of Standards; and the National Academy of Sciences, Building Research Advisory Board.

The codes approved were:

(1) Structural Steel Construction—"Specifications for Design, Fabrication and Erection of Structural Steel for Buildings (Riveted, Bolted and Arc-welded Construction)" revised June 1949. Copies—American Institute of Steel Construction, 101 Park Avenue, New York 17.

(2) Reinforced Concrete Construction — "A.C.I. Standard Building Code Requirements for Reinforced Concrete (A.C.I. 318-15)." Copies—American Concrete Institute, 18263 W. McNickols Rd., Detroit 19, Mich.

(3) Lumber and Timber Construction — "National Design Specification for Stress-Grade Lumber and its Fastenings, 1944; revised 1950." Copies — National Lumber Manufacturers Association, Washington, D. C., 25 cents each.

(4) Plumbing — "The National Plumbing Code," June, 1951. Copies of this code, developed by the National Plumbing Code Committee and issued jointly by the U. S. Department of Commerce and the Housing and Home Finance Agency, may be obtained from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., at 50 cents each.

Washington Briefs

Edward B. Arenson, president of the Toledo Iron and Steel Company, Toledo, Ohio, has been appointed consultant on NPA's production controls staff. He will handle construction problems under the Controlled Materials Plan. Mr. Arenson served in the Materials Section of the Navy Bureau of Ordnance and was engineering officer of the Philadelphia Naval Ammunition Depot during World War II.

A Committee on Specialized Personnel to make recommendations for the most effective training and use of the nation's scientists and technical personnel in the defense mobilization program has been appointed in the Office of Defense Mobilization. The committee is composed of 14 persons from government and private industry. Chairman is Arthur S. Flemming, assistant on manpower policy to ODM Administrator Charles E. Wilson.

A survey of petroleum transportation facilities is being made by the Petroleum Administration for Defense. The study will cover existing facilities for the movement of petroleum and its products by pipelines, tankers, barges, tank cars and tank trucks.

BRIEFLY STATED

• The American Welding Society's Committee on Metallizing has organized a test program to determine the corrosion resistance of steel having metallized coatings of zinc and aluminum under exposure to different atmospheres. Preparation of the more than 4,000 specimens to be exposed is already underway. When the specimens are completed early this fall, they will be assembled for exposure at such standard corrosion test sites as those located at Kure Beach, N. C.; Point Reyes, California; Gulf Coast; New York City and Wrightsville Beach, N. C.

• The Baltimore Aircoil Co., Inc., Baltimore, Maryland, manufacturers of evaporative condensers and cooling towers, announces that A. H. Norris has joined their organization as chief engineer. Mr. Norris has recently been associated with the firm of Lloyd E. Mitchell, Inc., as chief air conditioning engineer. Among his contributions to the science of heat transfer and air conditioning is his psychrograph which he developed in 1931. This advanced form of psychrometric chart is currently used by the Westinghouse Electric Corp. under agreement with Mr. Norris.

• The Holland-American Line's S.S. Ryndam, which recently completed its maiden voyage to New York from Rotterdam, is the first ship of foreign construction to be fully air conditioned since the close of World War II. The Ryndam carries air conditioning equipment manufactured by Carrier Corp., of Syracuse, N. Y. Her sister-ship, the Maasdam, which will be completed in 1952, also will have Carrier air conditioning.

• Reuben N. Trane, president of The Trane Co., La Crosse, Wis., recently received a special citation from the University of Wisconsin for his "leadership, ingenuity, engineering skill, and many significant contributions to development of better living conditions."

• J. C. Linsenmeyer, works manager, was elected vice president in charge of manufacturing at the June meeting of the board of directors of the American Blower Corp. John Brennan was appointed chief engineer; E. W. Petersen was elevated to the newly-created executive post as assistant general sales manager; and Benjamin Ragland was made manager of the Hydraulic Coupling Division.

• Fred Riedel has been appointed chief engineer of the Baker Refrigeration Corp., South Windham, Maine.

• Iron Fireman Manufacturing Co., Cleveland, Ohio, has announced the election of J. M. Mackay as director, executive vice president and general manager of the Iron Fireman Manufacturing Co. of Canada Ltd., at Toronto, Ontario, Canada.

• No early change in construction trends is likely to result from a cease-fire in Korea, according to Thomas S. Holden, president of F. W. Dodge Corp.

• A Department of Information Services has been formed by Westinghouse Electric Corp., Pittsburgh, Pa. All functions of public relations, employe relations and related activities will be included in the new section. Heading the new department as director of information services is Dale McFeatters, who has served as director of employe information since joining Westinghouse in 1945. Prior to that time, he was business editor of the Pittsburgh Press for six years. In his new position, he will report directly to Gwilym A. Price, president.

• American Radiator & Standard Sanitary Corp. has revealed expansion programs today costing nearly $4 million at two plant locations. Involved are the corporation's Elyria, Ohio, plant and the Stamping Plant in Buffalo, N. Y.

• Announcement of the election of John W. James as vice president in charge of research was recently made by McDonnell & Miller, Inc., Chicago, manufacturers of boiler safety devices and related products. Mr. James, who joined the McDonnell & Miller organization in 1948 to inaugurate an intensive research program, is widely known in the heating industry for his activities in professional societies, as a consulting engineer, and as author or co-author of many authoritative engineering papers and text books on heating and air conditioning. Having received his degree in Mechanical Engineering at Oregon State College, followed by a master's degree at University of Wisconsin, Mr. James devoted a number of years to design work with an Oregon consulting engineering firm. His activities have included three years as instructor, thesis, and research adviser at Polytechnic Institute of Brooklyn, and for five years before joining the McDonnell & Miller organization he participated in design and development work for a prominent manufacturer of domestic oil burners, furnaces, boilers, stokers and gas fired equipment. Mr. James is best known by many heating engineers for his eight years as Technical Secretary of the A.S.H.V.E. He is co-author of the text book "Heating and Air Conditioning," was technical editor of the A.S.H.V.E. Guide for many years; is a contributor to Kent's Mechanical Engineer's Handbook, and is author of a long list of articles in engineering publications.

• On June 30, 1951, a contract was signed between the Federal Government and the National Academy of Sciences at the request of the Defense Production Administration for advisory services by the Building Research Advisory Board on the subject of conservation in building construction. Howard Coonley, director of the Conservation Division of the Defense Production Administration, initiated the request shortly after organizing in the Conservation Division a Sub-Committee for Building Construction. This committee includes representatives of all government agencies concerned with federal construction, both military and civilian. James W. Follin of the General Services Administration has been designated as chairman of the Building Construction Sub-Committee. William H. Scheick, executive director of the Building Research Advisory Board, was named to this committee for liaison between the committee and BRAB.

How to Stop CONDENSATION!

Prevent Damage to Wood, Plaster, Paint, etc.

Condensation forms when temperature of contacting air is reduced below dew-point by a cold surface.

Condensation forms when the capacity of an air space at a given temperature is too small for the amount of vapor present. →

As air grows colder, it can hold less vapor. Saturation increases until a dew-point is reached, and condensation occurs. The surface of a material colder than the contacting air it faces, and continuously losing heat on the other side, will continuously extract heat from the air by direct conduction. The denser and bulkier the material, the more heat will it extract and store before attaining room temperature, if it ever does.

For example, if ordinary insulation is installed with air spaces on both surfaces, it continuously absorbs and emits heat rays at a rate of over 90%. If installed without air spaces, there is even more heat flow continuously by direct conduction through solids. Each square foot contains about 363,314 fibers, with surfaces aggregating approximately 46 sq. ft. for condensation formation.

With multiple sheets of accordion aluminum, the sheet nearest the warm room weighs only ⅛ oz. per sq. ft., absorbs and emits only 3% heat; thus extracts and stores practically no heat from the air, only enough to attain and remain at room temperature. The additional reflective air spaces on the other side are insignificant heat conductors. The other sheets of aluminum and fiber block convection heat losses to the "cold" side.

No condensation forms on the aluminum surface next to the warm room, for a dew point is never reached. The sheet's other surface faces a space which is a *little* colder than the aluminum. Since warmth flows to cold in radiation and conduction, the aluminum will *give off* a *slight* amount of *heat* to the colder space, thereby slightly *increasing* its vapor retaining capacity; making condensation impossible.

The next reflective space has almost the same temperature as the next aluminum surface, with its slight mass, ⅛ oz. per sq. ft. The aluminum absorbs and emits little heat. Its other surface is slightly warmer than the air it faces; again there is no extraction of heat (the REVERSE), no dew point.

With 4 or 6 reflective spaces, there can be no dew point anywhere on or in such aluminum insulation. Should rain leak in, it will be slowly expelled as vapor, since exterior walls, in comparison to aluminum have a far greater permeability than the required minimum 1 to 5 ratio. Because aluminum is impervious to vapor flow, condensation on under surfaces of roofs and inner surfaces of outer walls is minimized.

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—and for help with the temperature control, we'll talk to Honeywell!

Frankly, we'd hate to guarantee any plans drawn up by cartoonist Webb's mountaineers.

But they certainly have one mighty sound idea.

Honeywell *can* help heating engineers and contractors provide the proper thermal environment for any client—anywhere—in any kind of structure.

We have a lot of literature on the automatic control of all phases of heating, ventilating and air conditioning. Information you should have in your files.

And we have a lot of very well informed control engineers—in our 91 different offices—who have a lot *more* information right at their finger tips.

So, why not *talk to Honeywell?* Why not *write* to Honeywell for complete information on the equipment discussed in the column across the page? And why not do it *now?*

MINNEAPOLIS
Honeywell

First in Controls

• A. H. Borchardt has been elected a vice president of Worthington Pump and Machinery Corp. He will have the overall responsibility for the sale of the corporation's entire line of pumping equipment, including centrifugal, reciprocating and vertical turbine pumps.

• A report discussing new low dust concentration measuring methods and their use to test experimental devices for protecting compression machinery from these low dust concentrations is now available to the public, the Office of Technical Services of the U. S. Department of Commerce has announced. The methods to test these instruments and the new dust measuring devices themselves are described in a report issued by the Bureau of Mines of the United States Department of the Interior as Report of Investigations 4782, *Investigation of a Photoelectric Device for the Determination of Low Concentrations of Dust*, by D. I. Stone, L. J. Kane, T. E. Corrigan, H. W. Wainwright, and C. B. Seibert. A limited number of copies are available without charge upon request to the Publications Distribution Section, Bureau of Mines, 4800 Forbes Street, Pittsburgh 13, Pa.

• At a cost of less than one cent a ton, more than 120,000,000 tons of bituminous and anthracite coal have been saved from fire and destruction as the result of a Bureau of Mines program of controlling fires in inactive coal deposits throughout the United States during the past three years. At current market prices, it is estimated that this coal would be worth over $500,000,000 when mined. Since Congress authorized the fire control work in the 1949 fiscal year, a total of 21 projects—most of them now marked "completed" on the records—has been undertaken by the Bureau of Mines in widely scattered areas of the country. Some of the fires in inactive coal deposits had been burning for a generation or more.

• A new aluminum smelting plant, the first in history to use lignite (sub-bituminous coal) for fuel, will be built by Aluminum Company of America. The company has applied to the Department of the Interior for a certificate of necessity to begin construction of the plant in the immediate future at one of several alternate locations approximately 60 miles south of Waco, Texas, near large deposits of lignite. The large amounts of electricity required by the new plant will be generated by steam-driven equipment using processed lignite as fuel.

• The W. B. Connor Engineering Corp., manufacturers of ventilating and air conditioning specialties, announce the appointment of Harold F. Hagen as design and engineering consultant. Mr. Hagen, for over 25 years, was vice president and director of research of the B. F. Sturtevant Co. and he also held a professorship of the practice of mechanical engineering at the Graduate School of Engineering of Harvard University. Mr. Hagen's commercial work includes the design of the fans for most of the country's vehicular tunnels, among them the Holland, Lincoln second tube, Queens Midtown and Brooklyn-Battery tunnels in New York. The high efficiency backwardly-curved blade fan and the first quiet high speed axial flow fan for the ventilation of public buildings and Navy hulls, respectively, are among his developments.

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For help with any control problem, talk to Honeywell!

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In addition to the electronic relay 1) and space thermostat 2), the system incorporates duct thermostats, immersion thermostats, and motorized valves and dampers.

This system costs less to operate, too — because only when outside air is too warm to use for cooling does the system call for refrigeration.

So whenever you're planning temperature control for stores, offices, restaurants, theatres or any other kind of structure, be sure to call for Honeywell Electronic Air Conditioning Control.

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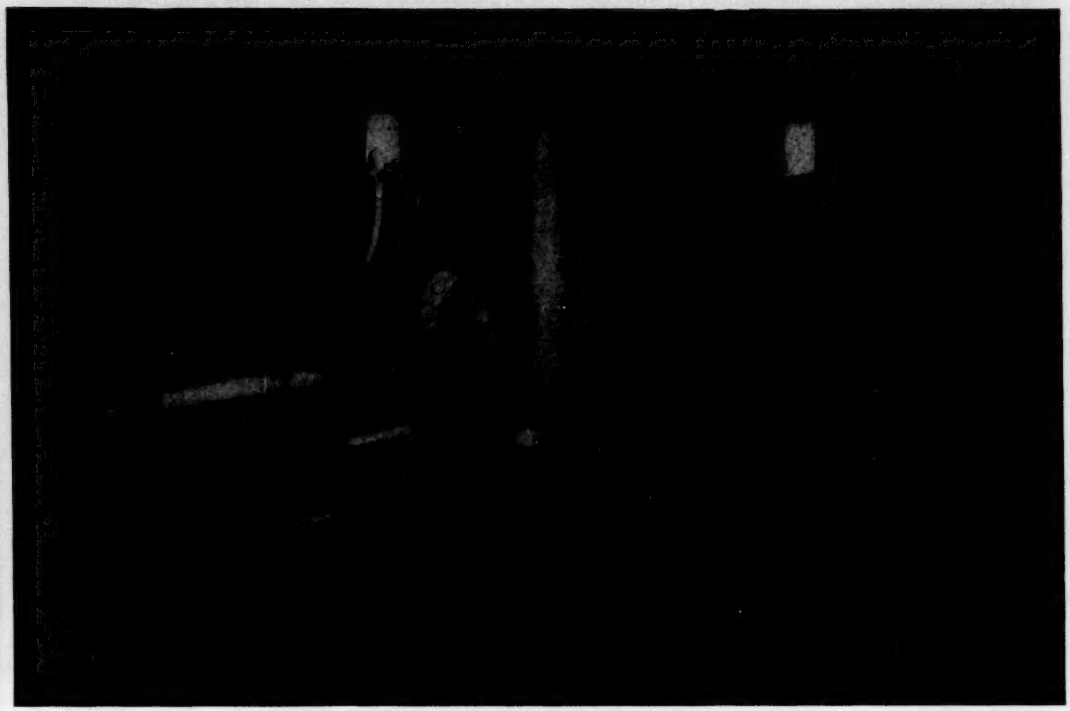


JENNINGS CONDENSATION PUMPS

Designed for steam systems on heating, drying, or process work, these pumps offer the most reliable and efficient means of returning hot condensate to boiler or hot well. In many cases these pumps will save costly installation of boilers in a pit to provide gravity flow of returns from basement radiators and heating devices.

The Jennings Condensation Pumps are sturdy and compact in construction, and combine receiving tank, pump and driving motor in a single assembly. Pumps are bronze fitted throughout, with tobin bronze shaft. The pumping impeller is of special design, made possible by our wide experience with return line heating pumps, and is especially adapted for handling hot water with the greatest possible efficiency.

Full automatic control is furnished by means of a ball float and float switch mechanism mounted on the receiving tank. All wiring is made up at the factory, and it is necessary only to connect the pump to the system and hook up the leads. Complete information regarding these economical pumps sent promptly on request.

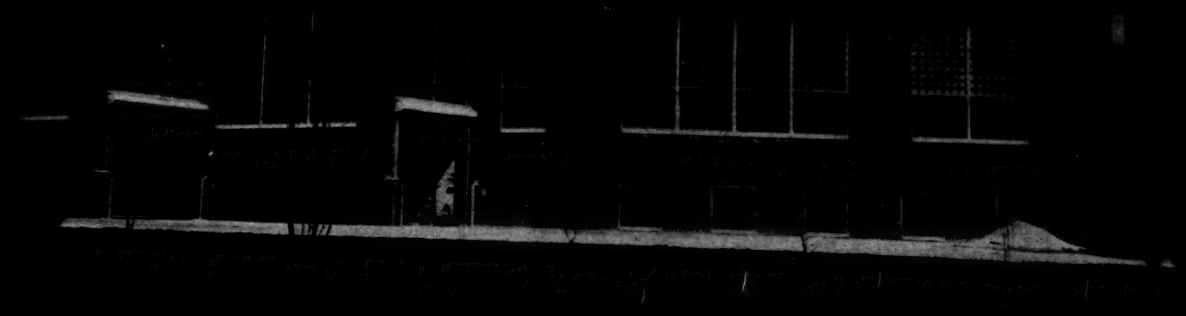
THE NASH ENGINEERING COMPANY

SOUTH NORWALK, CONNECTICUT, U. S. A.

Large-Scale Odor and Dust Control

Results in Nuisance-Free Refuse Handling Station

WM. A. XANTEN
Superintendent, Division of Sanitation, Washington, D. C.



Within a few thousand feet of Congressional office buildings is the new District of Columbia refuse transfer station handling tons of dusty, malodorous garbage and ashes daily. Dust-free odorless operation is assured by a ventilating, filtering, and deodorizing system which has proved effective through a full summer and winter of operation.

THE objective in providing a centrally located Refuse Transfer Station for the District of Columbia was primarily to reduce truck haul for collection units operating in the heart of the city and to provide a modern building for the transfer of garbage and other refuse from municipal collection trucks to 30 cubic yard tractor-trailers, gondola railroad cars, and the units of pig-feeders (to whom most of the municipal garbage is turned over). In passing the enabling legislation, Congress was aware that such a building would be located within a few thousand feet of the U. S. Capitol, and House and Senate Office Buildings and wrote a proviso into the law that the structure be equipped for odor and dust control.

While such a plant was considered essential for the transfer of garbage, one of its most important functions was also to provide a place for transferring other types of refuse, such as incinerator residue, street sweepings, ashes, and other non-combustibles for bulk shipment to existing land-fills which are rapidly becoming located farther and farther away from the center of the city. Table 1 indicates on a monthly basis the average daily quantities of refuse to be handled at this Transfer Station. The quantities shown are not total production, and with the exception of municipally collected garbage, which is all hauled to this plant, the loads shown as incoming are from limited areas of the city only. Total district-wide production of various types of refuse for the year ending June 30, 1950, was 4,101,071 cubic yards.

The Transfer Station is 270 ft long (with both entrance and exit ramps on opposite sides of the building for an over-all length, including ramps, of 540 ft) and 140 ft wide and planned to accommodate gondola railroad cars on one side and trailers on the other (see Fig. 1). The Station was designed for handling four gondola cars along a dumping rail on one side of the building with provision for four additional cars on a parallel track, all within the building. Four separate two-truck capacity stalls were provided on a saw-tooth arrangement on the south side of the building for depositing refuse into trailers. By the use of interior

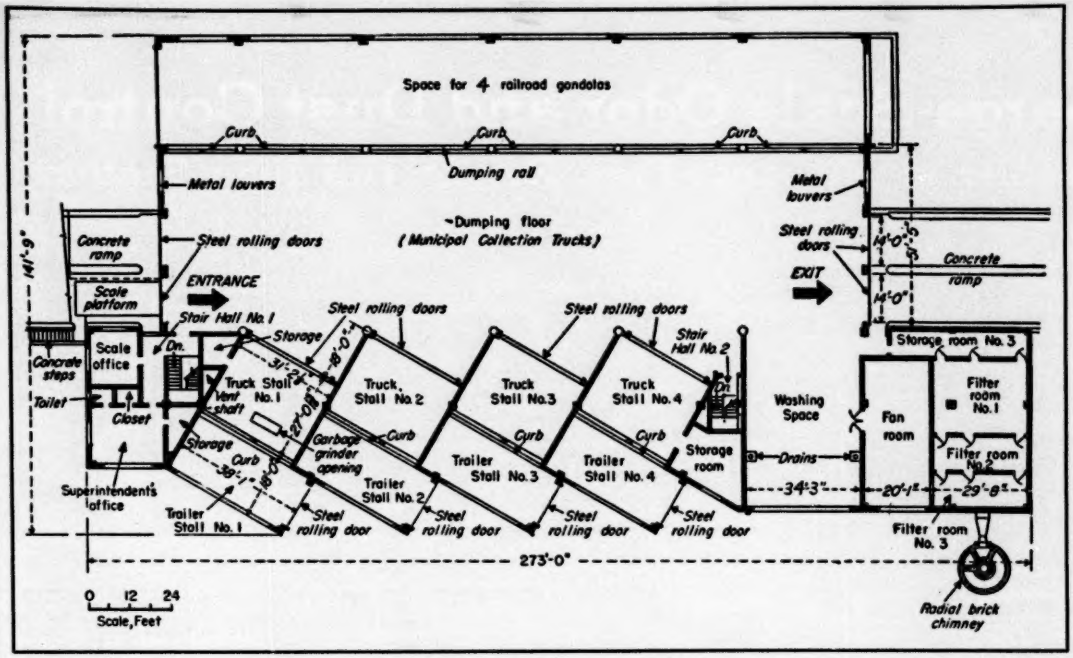


Fig. 1. Plan of refuse transfer station.

and exterior electrically operated overhead doors each one of these stalls may be sealed off during the dumping of trucks containing ashes and other refuse while the stall is thoroughly exhausted of the dust created. All refuse is weighed and the building is equipped with a truck washing room, a garage under the dumping platform for truck and trailer storage, and squad rooms and modern locker and shower facilities for the employees of the garbage service.

The dual problem of controlling both odor and dust emissions from this Station in the face of the rather heavy daily concentrations of refuse and the relatively large volume of air to be dealt with was a matter of some concern, requiring special study and some pioneering. The District was assisted by a special review of the preliminary design by the firm of Greeley and Hansen of Chicago.

To facilitate such control, the building was, in general, divided into two sections; i.e., the space under the main platform being reserved for garage, squad rooms, heating plant, etc.; with the upper or main portion of the building being provided with ventilation designed for the treatment of air. Fan capacities for this upper floor to provide approximately seven changes of air per hour were calculated at 85,300 cfm, with 26,800 cfm concentrated in the trailer stalls (the dust side), and 58,500 cfm on the railroad siding (odor side). Intake louvers were especially designed to concentrate most of the capacity as near the source of dust and odor as possible as well as at entrance and exit doors. The air from the trailer stalls is passed through cyclones before being introduced into the filter and canister room in order to insure minimum dust loading. Provision was made to by-pass ventilating air directly to the chimney during times when treatment for dust and odor control is unnecessary.

Vented air from both the odor and dust side of the

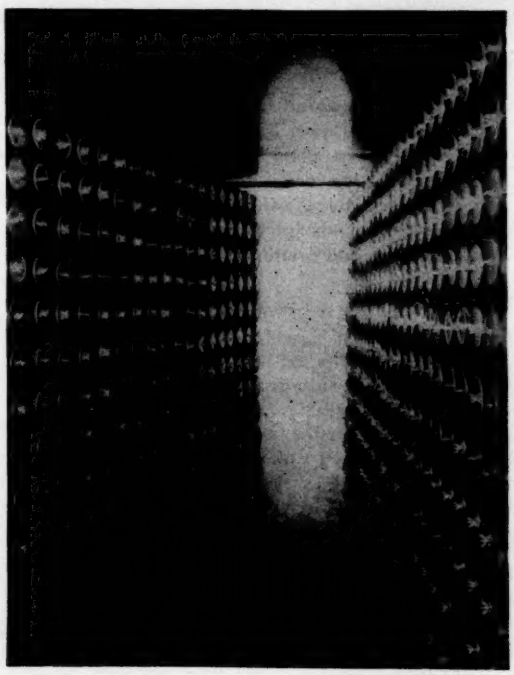


Fig. 2. Activated carbon canisters deodorize air.

TABLE 1—NUMBER OF LOADS TO BE TRANSFERRED PER DAY UNDER NEAR-FUTURE CONDITIONS.

Month	Incoming Trucks					Outgoing Gondola Cars, Farmers' Trucks and Trailers		
						Garbage By		All Other Refuse By Trailers
	Garbage	Street Refuse	Ashes	Incinerator Residue	Total	Gondola Cars	Farmers' Trucks	
	Loads Transferred per Day							
Jan.	101	70	56	13	240	2	89	28
Feb.	84	70	56	13	223	2	73	28
Mar.	84	70	55	13	222	2	73	28
Apr.	84	72	45	13	214	2	73	28
May	83	76	29	13	201	2	72	28
June	106	67	21	13	207	3	77	20
July	128	87	15	20	250	3	80	24
Aug.	123	80	13	16	232	3	81	22
Sept.	132	81	21	17	251	3	97	24
Oct.	90	119	30	16	255	2	73	33
Nov.	101	121	42	15	279	2	87	36
Dec.	85	89	57	15	246	2	70	32

Note: Since the erection of this station the municipality has discontinued the operation of its Garbage Reduction Plant which was located on the banks of the Potomac River at Cherry Hill, Virginia, about 35 miles south of Washington along the line of the R.F.&P.R.R. and instituted in lieu thereof at this location a sanitary fill for the handling of non-combustible refuse, garbage and large dead animals. Rail shipments of straight garbage have been practically discontinued and a somewhat larger percentage of municipally collected garbage is now turned over to pig-feeders. Also, a ten-ton per hour garbage grinding unit was installed in the Transfer Station to handle garbage disposal problems.

building may be passed through filters and 3,420 Dorex carbon canisters, each capable of handling 25 cfm, thereby effecting a 95% removal of all offending odors. While the over-all cost of the building, including railroad spur and engineering was $918,700, it is significant that the cost of the equipment for odor absorption, filters, and cyclones was but $37,400.

The chimney of the building is 100 ft high, and was divided into four sections or ducts. The center duct is round and receives air from the heating system. The outer annular space is divided into three ducts for a portion of the height (45 ft); one for the large fan ventilating the odor side of the building, and two smaller ducts for the dust control fans (trailer side).

The decision to use spun glass filters and activated carbon for final treatment was prompted somewhat by the fact that the odor and dust control system would be operated only a small percentage of the time, but when needed would have to be highly effective. Most of the refuse being delivered to the Transfer Station is concentrated in the middle of the day, with the odor problem being of most concern during the summer months and the dust problem of greatest concern during the winter months (ash season). Experience under actual operating conditions during a full winter and summer has proven the system to be both flexible and highly satisfactory.

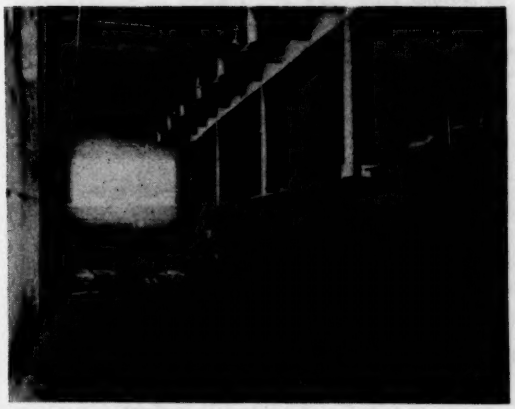


Fig. 3. Gondolas are loaded from trucks on raised dumping floor (behind cars).

Another feature which is conducive to maintaining cleanliness within the building was the provision of ample facilities for use of water. Standpipes are installed at the entrance of each trailer stall. Drainage from the main dumping platforms was handled so as to permit washing down without fear of clogging, and all drainage troughs are provided with catch basins. All heating units were confined to the garage and basement portion, with heating for the main station (except for office and weigh room) obtained by radiant heat from the platform slab.

The preliminary plans and layout for this plant were handled by the Division of Sanitation, Department of Sanitary Engineering, with final design and specifications by the Municipal Architect, D. C.

The use of transfer stations for handling the long distance bulk-shipment of large quantities of non-combustible wastes, including incinerator residue, will apparently be a requirement for most of the larger cities of the country sometime in the not too distant future. In order to locate them strategically, it would appear desirable that every effort be made to make their operation as nuisance-free as possible.

Flow of Viscous Fluids Simplified

Electrical circuit heating system makes possible flow of heavy fuel oils for intermittent operation of oil burners, and the transport of viscous industrial fluids through long pipe lines.

COMBUSTION of heavy oils as No. 5 or No. 6 fuel in oil burners requires some type of pipe heating to make these heavy, viscous fluids free flowing. While steam has been used for such service, a patented system called Thermal Electric,* was developed by Fluid Systems, Inc., New Haven, Conn., and has been used for automatic, intermittent oil burner operation. Electric power is used.

Basically, the component parts of the system consist of a Low Density Automatic Electric Immersion Heater, installed in the return line, a Tank Unit which permits the heated oil in the return line to mix with unheated oil in the storage tank to supply oil of the proper temperature, an electric thermostat to control the time the immersion heater is to function, and a Transforming Energizer, which is connected to the 230-volt power feed to supply power at low voltage, impressed on the pipe wall itself. Resistance of the pipe to electric flow causes conversion of electric energy to heat. While this heat is not enough to raise the temperature of the oil in transit through the pipe, it is sufficient to compensate for the Btu loss through the pipe installation so that the supply line can be maintained at uniform temperature.

The Tank Unit is illustrated in Fig. 1. For the purpose of explanation, assume that a burner has a pumping rate of 100 gph and that it is burning 50 gph oil and returning the balance of 50 gph to the storage tank. Therefore, the return oil in this case must be heated to 180F by means of the return line heater, so that when mixed with the 50 gph of 60F fuel from the storage tank, the temperature of the oil supplied will be 120F. The supply line is designed to deliver fuel at this temperature.

There is an interesting sidelight to this. Although one No. 6 oil may have a radically different viscosity at 70F as compared with a similar type oil from another source, at 120F the readings of the two samples are about the same. Bunker oil takes on the characteristics of a light, free-flowing oil at 120F.

Since the fuel storage tank is installed underground, advantage is taken of the surrounding earth temperature which may heat the oil at the intake to about 50F, depending on individual conditions. The earth temperature, plus a small amount of heat supplied, raises the oil temperature near the intake to 60F.

The Tank Unit permits the mixing of the warm return oil with that drawn from the tank. It consists of two pipes, one installed inside the other with an air space between, and connected by contact spacers. Insulated Pipe Joints prevent the grounding of the electrical circuit to the tank. The inner pipe *A*, Fig. 1, is the suction, or feed line to the burner, while the outer pipe is the return line. The heated return oil tempers the oil in pipe *A*, and creates a small zone of heated oil adjacent to the outside of the return pipe. The Insulated Joint *B* provides an electrical separation of the suction from the return lines, so that the electric current travels from the suction connection down the suction pipe, through the special Contact Spacers, and back up the return connection. The bottom of the mixing unit is installed to be not less than 5 inches from the bottom of the tank. The vent hole *D*, drilled in the return pipe after installation, permits entrained air to escape.

Fundamentally, the Tank Unit is a device that keeps the oil in the supply pipe in a fluid state without the use of heating coils in the tank so that fuel may be pumped from storage without heating the entire storage tank. It has another purpose, for it serves to

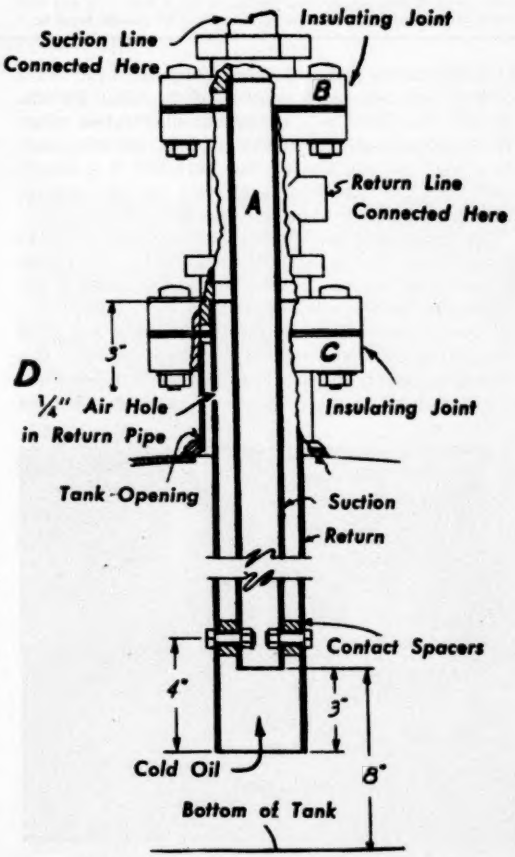


Fig. 1. Design details of unit in tank.

*"Thermal Electric" and "Fluid Systems, Inc." are trademarks registered in U. S. Patent Office.

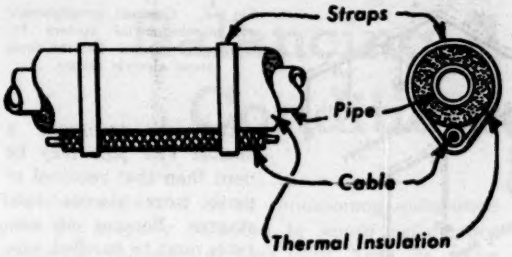


Fig. 2. Cable strapped outside of thermal insulation.

complete the electrical circuit so that heat will be supplied to the suction and return lines. Although the system is connected to 230-volt power lines, the Transforming Energizer converts this to low voltage—not in excess of 20 volts. A temperature of 120F is maintained thermostatically under all conditions of flow and non-flow, in all piping. An interesting feature of unheated storage is the elimination of stratification or sludging when residual or blended fuels are used.

A Low Density Immersion Heater is installed in the return line from the oil burner. Various size heaters are available to meet variable flow rates. The thermostat, connected to the suction line, starts the Transforming Energizer when the pipe temperature drops below the predetermined 120F, the temperature of the fuel conveyed to the burner.

Average efficient burners, however, usually specify a maximum burning temperature of 150 to 160F. As a requirement of the Underwriters' Laboratories, an electric immersion heater is furnished with each residual fuel burner. To raise one gallon of fuel from 120F to 160F, requires 40 watts. At a power rate of 2¢ per kw, the cost is 2/25 of one cent.

The total cost of electrical heating for the entire system is 3/25 plus 2/25 or 1/5 cent per gallon burned. This operating cost is but a small part of the saving possible through the use of a bunker oil as compared with the cost of a lighter fuel.

In starting, after the system has been idle for many hours, as over a weekend, the switch is thrown to impress heat on all piping. Within about one-half hour, the fuel lines are "unfrozen" so the oil burner can function. For short shut-down periods, piping may be maintained at the 120F for immediate start-up, without cycle operation of the burner.

Industrial System

The electrical circuit in this application is possible because the return line is used also as the electrical circuit return. A different arrangement must be followed when the system is used in industry to make possible the flow of such heavy or viscous substances as pitch, molasses, glucose, chocolate, resin, paraffin, asphalt, corn syrup, vegetable oils, and fatty acids. This industrial application of electric heating for the supply line is used where a long pipe conveys the heavy, viscous fluid from the storage tank to the point where it is picked up for processing or packaging.

TABLE 1—PIPE LENGTHS FOR ECONOMICAL APPLICATION.

Temperature Differential, F	Pipe Diameter, Inches			
	1½	2	2½	3
	Length of Line, Feet			
240	250	250	255	280
260	240	240	250	270
300	220	220	250	250

Since there is no return line, some other means must be used to complete the necessary electric circuit. Thermal Electric Pipe Joints are used at intervals when assembling the pipe, and an electric cable run from the far end of the pipe line to the transformer is strapped to the pipe over the insulation, as in Fig. 2, and connected to terminals furnished with the Pipe Joints.

With the industrial system, two approaches are possible:

(1) Where steam, water, or direct-fired heating is available for warming the material in the storage tank, then the Thermal Electric System is used to replace the heat loss through the insulation covering the long transport line.

(2) The system can be used for maintaining a fluid state of the material during its transport through the feeder line, and thermostatically controlled electrical heating coils can be used for heating the material before it enters the feed line. Thermal Electric Heated Storage Units are also available.

While long transport lines are possible, Table 1 gives the economical pipe lengths for various temperature differentials and pipe sizes. Tandem systems are used for multiples of the listed lengths.

In both the oil burner and industrial applications, the pipe is covered with specified thermal insulation to limit heat loss to a design factor. Underground in-

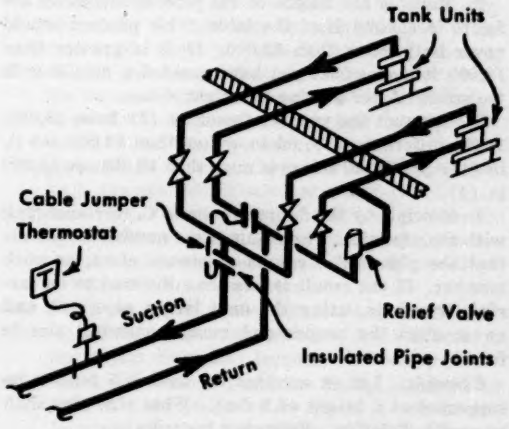


Fig. 3. Piping for a two-tank arrangement.

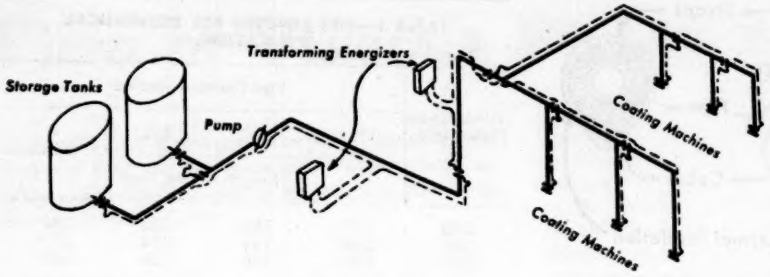


Fig. 4. General arrangement of an industrial system for transporting wax. Broken lines show electric return.

sulation is waterproofed to prevent the entrance of moisture.

By using the system described for maintaining the material at the proper temperature in the line for satisfactory transport, a smaller size pipe may be used than that required to move more viscous substances. Because only use-rates must be handled, piping is usually smaller than when circulation is utilized. A great deal depends upon the proper sizing of pipe and pump so that there will be the correct relationship between friction and pipe diameter in the long pipe lines.

Calculating the Strength of Pipe for Columns

Not long ago a contractor asked this question: "I am installing a tank that will be seven feet off the floor. When full of water the weight will be five tons. I want to hold it up with a pipe and would like to know what size of pipe to use. Will a 2-inch pipe be strong enough?"

Inasmuch as standard pipe often comes in handy for use as columns or for use as push members in transmitting forces, perhaps there are others who would like to know how to figure problems of this kind themselves. A pipe that is too small can cause disaster.

As a result, the writer developed the following simple rules and tables which make it possible for anyone to work out such a problem himself.

1. Knowing the load that is to be carried and the length of pipe needed, make a guess as to the size of pipe. Column A in the tables will help in making the guess as it gives the maximum length of pipe that may be used. Thus, never use a ⅛ inch pipe as a column longer than 14.5 inches. Never use a 3 inch pipe as a column longer than 139 inches.

2. Multiply the length of the pipe in inches by the figure in column B of the table. This product should never be greater than 12,000. If it is greater than 12,000 it means that you have guessed a pipe that is too small. After getting the right size:

3. Subtract the product found by (3) from 19,000. If the difference is equal to or less than 13,000 use it, in (4). If the difference is more than 13,000 use 13,000 in (4).

4. Multiply by the figure in column C, corresponding with the pipe size. The result is the number of pounds that the pipe will carry as a column, strut, or push member. If the result is less than the load to be carried, try again, using the next larger pipe size, and so on until the proper and most economical size is found.

Example. Let us say that the load is 5 tons to be supported at a height of 7 feet. What size pipe shall be used? *Solution.* Following the rules:

1. Column A shows that 84 inches (7 ft) falls between 1½ and 2 inch pipe. Try employing a 2 inch pipe.

2. Opposite 2 inch pipe find, in Column B, 126.9. Then 84 × 126.9 equals 10,650. This is less than 12,000, so continue.

3. 19,000 — 10,650 equals 8,350. This is less than 13,000 and may therefore be used in (4).

4. 8,350 × 1.07 equals 8,950, the number of pounds a 2 inch pipe will support as a 7 foot column. But since 8,950 is less than 10,000 pounds a 2 inch pipe is too small. Therefore recalculate, this time trying a 2½ inch pipe. Briefly, the results are as follows:

2. 84 × 105.3 = 8,850
3. 19,000 − 8,850 = 10,150
4. 10,150 × 1.71 = 17,370 pounds.

A 2½ inch pipe will therefore be amply safe to hold up 10,000 pounds at a height of 84 inches. In fact, the result shows that a 2½ inch pipe is capable of holding nearly twice as much as a 2 inch pipe at that height. The small difference in pipe sizes and the great difference in strength makes clear the necessity for computation and the danger involved in guesswork.

The foregoing rules are based on the well known American Bridge Co. formula—*W. F. Schaphorst.*

Size of Pipe, Inches	Column A Maximum Length, Inches	Column B	Column C
⅛	14.5	826.4	0.07
¼	19.4	617.3	0.12
⅜	25.	480.8	0.17
½	31.3	383.1	0.25
¾	40.	300.3	0.33
1	50.6	237.5	0.50
1¼	64.7	185.5	0.67
1½	75.	160.5	0.80
2	94.7	126.9	1.07
2½	114.	105.3	1.71
3	139.	86.21	2.24
3½	161.	74.63	2.68
4	181.	66.23	3.18
4½	202.	59.52	3.68
5	226.	53.19	4.32

Balancing Air Flow in Air Conditioning Systems

The duct system of an air conditioning installation must be properly balanced to insure satisfactory operation. Engineers of York Corp., York, Pa., have compiled these easy step-by-step instructions for use in balancing small, medium or large systems.

THERE are two important reasons for checking the performance of air conditioning installations as soon as they are placed in operation. They are:

(1) To see that each part is operating correctly.

(2) To see that the various parts and their functions are coordinated.

This coordination is generally termed "balancing" and is necessary on the small job as well as the larger one. A time-saving step in balancing is to tabulate the air quantities for the system. While the following list will cover any installation, some of these items may be omitted for the small jobs.

Maximum outside air and percentage of total fan cfm.
Minimum outside air and percentage of total fan cfm.
Maximum return air and percentage of total fan cfm.
Minimum return air and percentage of total fan cfm.
Maximum cfm through washer and percentage of total fan cfm.
Minimum cfm through washer and percentage of total fan cfm.
Total cfm main fan.
Minimum cfm main fan (on volume control jobs).
Total cfm each booster fan.
Maximum cfm cooled air to booster fan.
Minimum cfm cooled air to booster fan.
Maximum cfm by-passed air to booster fan.
Minimum cfm by-passed air to booster fan.
Maximum by-pass at washer and percentage of fan capacity.
Minimum by-pass at washer and percentage of fan capacity.
Guarantees for both the percentage humidity and temperature.
Estimated dewpoint of air out of washer.
Jobs are divided into these classifications: Small air conditioning systems; medium or large air conditioning systems; systems using booster fans; volume control jobs.

These classifications cover practically all the installations the average service engineer will be called upon to balance.

Balancing Small Air Conditioning Systems

To balance small air conditioning systems, proceed as follows:

(1) See that all the filters installed as part of the system are clean.

(2) Start the fan. With forward curved blade fans and variable pitch pulleys see that the motor is not overloaded by excessive fan speed.

(3) Examine all supply and return grilles to see that they are each getting air, and that there are no restrictions.

(4) Block the face damper so it is open and the by-pass damper closed.

(5) By means of velocity measurements on the return and outside air inlets, set these two air quantities so that they are in the same proportion as the job conditions require (for example, 75% return air and 25% outside air) regardless of what their actual values may be. The air velocities may be read by means of anemometer, velometer, or pitot tube, as convenience dictates.

(6) Take anemometer readings at the grilles and convert these to cfm to get the total air quantity handled by the fan. If this is within 10% of the estimate, adjustment of the fan speed is unnecessary. If the cfm differs more than this from the required value, change the fan speed in the proportion of cfm required over cfm obtained. Note: The cfm may be obtained also by pitot tube readings in the fan discharge, if convenient.

(7) Select one outlet and take an accurate velocity reading (record for further reference).

(8) Open the by-pass damper and partially close the face damper.

(9) Again take a velocity reading at the selected outlet or grille. If the velocity read is below that observed under (7), the face damper should be opened until the velocity corresponds within 10% to the value obtained under (7). If the observed velocity is higher than obtained under (7), move the face damper toward the closed position. Mark the damper position finally obtained. Note: Instead of observing grille velocities, the above procedure can be followed by using in the same manner, the static pressure in the fan discharge.

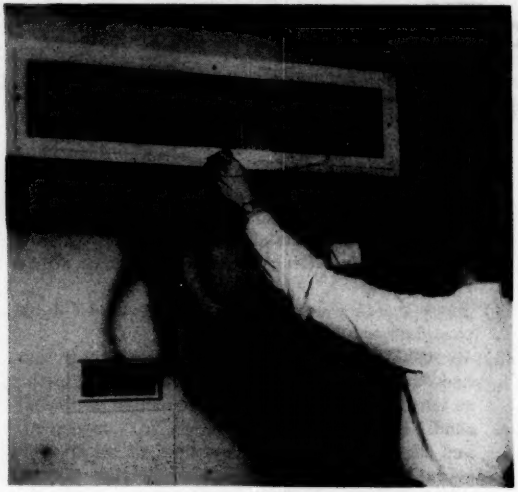
(10) Adjust the damper motor linkage so that with the damper motor at one end of its travel, the by-pass will be closed and the face damper wide open; and at the other end of its travel, the by-pass will be wide open and the face damper will be in the position determined under (9).

(11) Set the splitters and dampers so that each grille delivers the required cfm by means of anemometer or velometer readings (generally readings within 10% are close enough).

(12) Place the system under automatic control.

(13) Check the room temperatures for uniformity, and adjust the grilles further if necessary.

(14) Mark all damper positions finally obtained so that if a complaint arises later, it can be determined whether the position of the damper (or dampers) has been moved.



Air flow being measured with a velometer.

Balancing Medium and Large Systems

General—While these systems may vary considerably in size or in the extent of the duct distribution, the same general procedure for balancing may be followed on all jobs. In any case, it should be done in a systematic manner by keeping a complete set of records of every operation, and the results obtained. Furthermore, the larger the job, the more difficult it is for an engineer to assimilate the details of the installation in a short time. For this reason, it is good practice, as well as economical, to have someone available who is familiar with the location of all dampers and splitters.

As mentioned before, the apparatus should be balanced first. This procedure would be as follows:

(1) Examine the entire duct system to make sure all grilles, dampers and splitters are open for both supply and return.

(2) Start the fan. (If it is a forward curved blade fan, see that the fan motor is not overloaded.) Note: If the ducts are dirty, it may be necessary to cover the outlets temporarily with cheesecloth to catch the dirt.

(3) Examine the filters to see whether they are dirty or not, as testing should be done with clean filters.

Setting Outside and Return Air Dampers—The following steps are taken in checking dampers:

(4) Open the minimum outside air damper to its approximate setting, and close the maximum outside damper.

(5) Close the by-pass damper and open the return air dampers. By means of velocity measurements on return and minimum outside air dampers, set these two air quantities so that they are in the same proportion as the job conditions require (such as 75% return air and 25% outside air, for example) regardless of what their actual values may be. The air velocities may be read by means of anemometer, velometer, or pitot tube, as convenience dictates.

(6) Take a static pressure reading on the fan discharge.

(7) Close the by-pass, open the maximum outside air damper, and close the return damper.

(8) Take a static pressure reading as in (6). If this static pressure is lower than in (6) the outside air intake is restricted. If the resistance cannot be removed, block the return air damper partially open so that the fan discharge static pressure is equal to that observed in (6). Install a permanent stop on the damper. If the fan discharge static pressure is higher than in (6), block the outside air damper partially closed so that the fan discharge static pressure is equal to that observed in (6), and install a permanent stop on the damper. Note: By means of this procedure, outside and return air dampers have been set so that the same total air quantity will be handled with the dampers in the positions corresponding to maximum and minimum outside air. The next step is to set the by-passes.

Setting By-pass Dampers—There are two cases, washers with and without face dampers. If face dampers are used, it is possible to set the face and by-pass dampers so as to keep the total cfm constant for any position of these dampers, and at the same time to give the designed maximum and minimum cfm through the washer. The procedure is as follows:

(9) With the by-pass closed, and face, return, and minimum outside air dampers opened, read and record the fan discharge static pressure.

(10) With the by-pass, minimum outside air and return air dampers open, move the washer face damper to such a position that the fan discharge static pressure reads the same as in (9).

(11) By means of anemometer, velometer, or pitot tube readings, determine the cfm through the by-passes and the washer when the dampers are in the position determined by (10). If the portion by-passed exceeds the design quantity, add resistance to the by-passes. If the proportion by-passed falls below that required, by-pass is restricted and must be relieved.

(12) By trial and error, repeat steps (9), (10) and (11), until the by-pass resistance and face damper position are found which give the design proportion of by-passed and washer air when the by-pass is wide open and at the same time give the same fan discharge static pressure with the dampers in positions described in (9) and (10).

(13) Adjust the damper motor linkage so that with the damper motor at one end of its travel, the by-pass will be closed and the face damper will be in its minimum open position as determined in (12); and with the damper motor at the other end of its travel, the by-pass is closed and the face damper open. Note: When the washer is not fitted with face damper, it is not possible to keep the total air quantity constant with the by-pass damper in open and closed position, the cfm variation depending on the portion of the total system resistance represented by the washer. In such cases, the procedure is as follows:

(14) With the by-pass closed and return and minimum outside air damper open, observe the fan discharge static pressure.

(15) Open the by-pass and observe the fan discharge static pressure. If this exceeds the static pressure observed in (14) by more than about 20%, resistance must be added to the by-pass until the static pressure increase at the fan discharge falls within 20% of the value in (14).

(16) By velocity readings over the face of the washer and in the by-pass, determine the proportion of by-passed to washer air with the by-pass open. If the proportion of by-passed air exceeds the design value, add resistance to the by-pass by trial until the design proportion is reached. If the proportion of by-passed to washed air falls below that required, the by-pass is restricted and must be relieved. The limit of relieving the by-pass is fixed by (15) above. If after the limit of static pressure given in (15) has been reached and there is still insufficient by-passed air, a washer face damper must be used, in which case the adjustment is as described in (9) to (13) inclusive.

Setting Total Air Quantity—In establishing the setting for the total air quantity, proceed as follows:

(17) Take readings of the fan discharge velocity to determine accurately the cfm handled. If this cfm differs from the design value, change the fan speed in the proportion of cfm required over cfm observed.

(18) As a final check, read and record fan discharge static pressure and air quantities, and record as tabulated in Table 1. If the air quantities are not within 10% of the design volume, the previously described procedure should be checked through to find and correct the errors.

Balancing Duct Distribution

As in balancing the apparatus, the testing of the duct outlets should be done in a careful and systematic manner. The simplest procedure is to take the blueprints of the duct layout, and number each grille, splitter and damper. On the larger jobs, it is good practice to mark also the grilles, dampers, etc. In marking the prints, where the supply duct is divided into two or more branches, each branch should be numbered or lettered as well as the grilles, etc. For example, supply S-1 will have grille S-1-1, S-1-2, etc., and the return R-1-1, R-1-2, etc.

Tabulation of test results is very important and it will be found that careful recording will save considerable time. A sample tabulation is given in Table 2.

TABLE 2—RESULTS OF TESTS.

Date:.....

Job:.....

Supply duct No.	1	1	1	1	1	1
Grille No.	1	2	3	4	5	6
Estimated cfm	350	350	350	350	350	350
Grille area, sq ft	.78	.78	.78	.78	.78	.78
Est. velocity, fpm	450	450	450	450	450	450
Readings (1)	475	425	500	410	470	440
Readings (2)	460	440	440	470	455	465
Readings (3)	460	455	452	448	450	455
Readings (4)	.....	.....	.....	.....	.....	.....
Readings (5)	.....	.....	.....	.....	.....	.....
Final cfm	358	354	352	348	350	352
Damper	1	1	1	1	1	.....
Setting (1)	2	3	2½	3	3	.....
Setting (2)	.....	.....	.....	.....	.....	.....
Setting (3)	.....	.....	.....	.....	.....	.....
Setting (4)	.....	.....	.....	.....	.....	.....

Balancing Duct Systems

(1) When the cfm from the fan is correct, for all damper positions, determine the amount of air to be handled by each branch.

(2) Measure each branch at a suitable point, and from the estimated cfm figure the velocity of air in the duct.

(3) Convert velocity into pressure in inches of water.

(4) Take velocity readings in the branch ducts and set the splitter so that the velocity pressure will be as figured under (3). Note: It is not necessary to take a complete transverse of the duct, but for this purpose three or four readings is all that is required in large ducts.

(5) When the cfm to all the branch supplies are approximately correct, select one branch and take reading of all grilles, record and compare these with the estimated velocities.

(6) From the tabulations of the grille test, note which ones have higher velocity than estimated, and set the dampers or valves to reduce the air quantity to these grilles. This will automatically increase the cfm of the grilles which have low velocity.

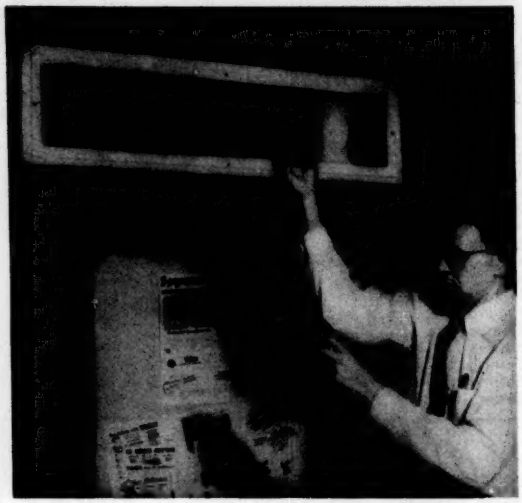
(7) Repeat the readings as under (5) and (6) until all are within 10% of estimate.

(8) Proceed in a similar manner on the remaining branches.

(9) Make up a tabulation of the return grilles similar to the tabulation for the supply grilles.

TABLE 1—RECORD OF DATA IN MAKING CHECK ON AIR QUANTITY.

Item	Est. Cfm	Test 1	Test 2	Test 3	Test 4
By-pass damper		Closed	Closed	Open	Open
Return damper		Open	Closed	Closed	Open
Outside dampers, minimum		Open	Open	Open	Open
Outside dampers, maximum		Closed	Open	Open	Closed
Face damper		None	None	None	None
Maximum washer cfm	17,800	18,000	18,000		
Minimum washer cfm	9,500			9,600	9,500
Fan speed	428		430		
Fan discharge static pressure, inches		.62	0.63	0.62	0 63
Velocity at eliminator		750	750	400	400
Minimum by-pass cfm					
Maximum by-pass cfm	8,300			8,400	8,400
Minimum outside air cfm	5,000				5,200
Maximum outsde air cfm	17,000		18,000		



Anemometer readings being taken at grille.

(10) By means of an anemometer, determine the cfm on the return grilles and set the dampers so each handles the correct amount.

(11) Take wet and dry bulb readings in various areas to determine the uniformity of temperature and humidity and adjust the supply grilles if necessary.

Balancing Systems Using Booster Fans

On installations using booster fans, the by-pass air is handled at each zone fan, and there is no by-pass at the main apparatus. The balancing of such a system is done substantially in the following manner:

Setting of Outside and Return Air Dampers—The following three steps should now be followed:

(1) Close the by-pass and open the dehumidified air dampers on all the booster fans.

(2) Proceed as (1) to (6) under Balancing Medium or Large Air Conditioning Systems.
Note: Under "Starting the Fan," the booster fans should also be started.

(3) Close the maximum outside air damper and open the return damper on the main supply apparatus.

Setting Total Air Quantities—This is a more extensive procedure and calls for the following steps:

(4) Close the dehumidified air and open the by-pass dampers on the booster fans.

(5) By means of pitot tube readings on the booster fan discharges, determine the actual cfm being handled by each fan. If this cfm differs from the design value, change the fan speed in the proportion of the cfm required over the cfm observed.

(6) When the cfm of each booster fan is correct, take the static pressure in the booster fan discharge.

(7) Open the dehumidified air and close the by-pass dampers on the booster fans.

(8) Set the splitters in the supply duct from the main fan so that each booster fan receives the correct proportion of the total cfm regardless of whether the total is correct or not. To do this, take the pitot tube readings and determine the total cfm from the main fan, and then take readings at each branch duct to the booster fans and set the splitters accordingly.

(9) Take a static pressure reading in the booster fan discharge. If this reading is 10% above or below the static pressure taken at (6), change the speed of the main supply fan by:

$$\text{New rpm} = \text{old rpm} \sqrt{\frac{\text{S.P. taken under (6)}}{\text{S.P. taken under (9)}}}$$

This procedure will be satisfactory when the cfm of the booster fan is equal to the cfm of dehumidified air from the main supply fan. When the booster fan cfm is greater than the cfm of dehumidified air supplied to it, such as when a constant amount of by-pass air is handled, proceed as under (1) to (8).

(10) With the by-pass dampers open and the dehumidified air dampers closed, take a static pressure reading in the by-pass air duct near the damper.

(11) Open the dehumidified air and close the by-pass dampers on all booster fans. If a hand by-pass damper is provided, open it slightly to an approximate position to handle the cfm of the constant by-pass; if not, block the automatic dampers partially open.

(12) By means of an anemometer or pitot tube, determine the cfm of the constant by-pass air and place a stop on the dampers when the correct position is found.

(13) Open the dehumidified air dampers and close the by-pass dampers to the stop.

(14) Take a static pressure reading in the dehumidified air supply duct, as near as possible to the damper. If this static pressure is more than 10% above or below the static pressure taken at (10), change the main supply fan speed accordingly. Note: While the static pressure taken under item (10) may not be the same on each fan, the difference between the static pressure taken at (10) and (14) should be the same for each fan.

(15) With the static pressure taken under (10) and (14) equal, the total cfm from the main supply fan should be correct. However, take pitot tube readings in the main dehumidified air supply duct to check. If it is not correct, the indication is that either the by-pass air dampers were not set correctly or the booster fans were not receiving the correct proportion of air as set under item (8).

(16) Take a static pressure reading in the discharge of the main supply fan and set the static regulator to maintain a constant static pressure (if a static pressure regulator is furnished).

(17) Open the by-pass damper and close the dehumidified air damper to the approximate minimum position.

(18) With a pitot tube, check the dehumidified air supply to each booster fan and set the dampers to the correct minimum position, and install stops.

Generator Hook-up Supplies Large Amounts of Hot Water

H. B. WILSON

Commercial Sales Manager, The Brooklyn Union Gas Co., Brooklyn, N. Y.

Summer operation of a space-heating boiler for supplying domestic hot water in large volume has always raised the question of efficiency of the system. A novel hook-up has been devised to permit a small gas-fired immersion coil boiler to supply hot water in summer and the main boiler to function during winter months.

FOR the past several years, The Brooklyn Union Gas Co., Brooklyn, N. Y., has been actively engaged in the volume water heating field because of the year-round heating load it provides and the important off-peak possibilities for the summer season.

During the course of the company's investigation, test data were obtained on water heaters and their operation in various types of water heating systems. During this work, what is believed to be a new and novel approach to many water heating problems was found. This new idea, the subject of this article, is referred to as the generator hook-up and it promises to have wide application.

It is likely that there will be a mounting interest in the subject of volume water heating within the gas industry for some years resulting from the growing use of natural gas. It is inevitable that this growth will be accompanied by the sale of great quantities of gas for house heating purposes during the winter months. Therefore, it is imperative from the utility standard that every effort be made to offset this load with its poor load factor characteristic with loads providing favorable load factors.

During this investigation, much attention was given to immersion coil water heating. This type of immersion coil water heating differs from the usual immersion coil water heating application where an immersion copper coil is installed in a large boiler chiefly used for space heating. In this investigation, attention was directed to equipment in which the boiler, burner and coil were designed to supply domestic hot water only. It was this phase of research that led to the generator hook-up idea. The immersion coil boilers used by Brooklyn Union are manufactured by the Viking Superior Corp.

Fig. 1 illustrates the method of connecting the large space-heating boiler with the much smaller gas-fired immersion coil water heater. It is probably best, in order to clearly describe this hook-up and its importance, to discuss the operation which is obtained from interconnecting two boilers in this fashion and later on to discuss the advantages.

During the winter months, the hot boiler water from the space heating boiler, whether cast iron or steel and regardless of which fuel is used, is pumped through the small gas-fired immersion coil boiler. This supplies the necessary hot water to keep the smaller boiler filled with high temperature water at all times. During the summer months the circulating pump is shut off and the gas burner is put into operation, thereby making it possible to shut down the large space-heating boiler which otherwise would be used inefficiently all summer long to supply domestic hot water. This idea has particular application in territories where the gas company has an off-peak rate available. It will be noted that the temperature of the hot water is regulated by means of a mixing valve.

When the large space-heating boiler is shut down, the two gate valves are closed, the valve at the bottom of the expansion tank is opened and the valve on the street side of the combination water pressure regulator and relief valve is opened. The boiler is then operated as a gas-fired hot water boiler during the off-peak

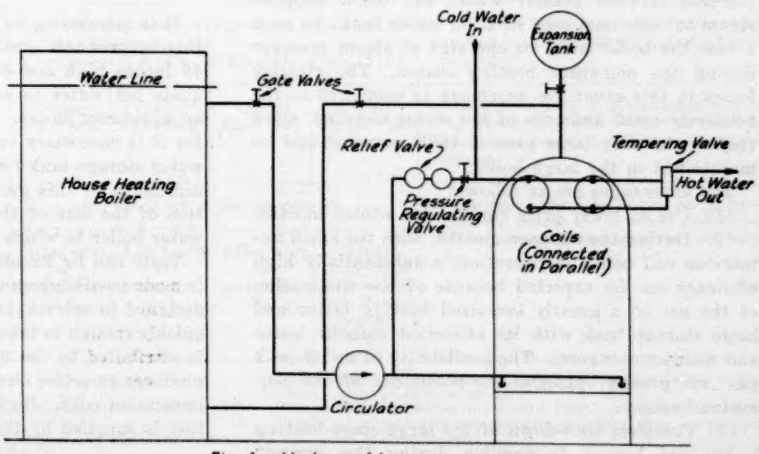


Fig. 1. Hook-up of hot water generator.

season. When the time comes to revert to winter operation, it is necessary to open both gate valves, close the valve at the bottom of the expansion tank, close the valve on the street side of the combination water regulator and relief and put the circulator in operation. The space-heating boiler, of course, would be equipped with the conventional relief device. It is recommended at this time that the aquastat in the small boiler be used to control the booster although satisfactory results may be obtained by using the aquastat in the outlet line from the copper coils.

As already stated, this hook-up is applicable to both steel and cast-iron sectional boilers. In the latter case, it is not necessary to tap each section of the cast-iron boiler because of the use of the forced circulator. In this case, however, it would be advisable to make the inlet and outlet connections of the boiler at locations which would insure the use of all of the hot water within the boiler, if needed.

Advantages

One of the best methods of illustrating the application of this generator hook-up is to consider its use in an apartment house. The application extends, regardless of fuel used, to almost any commercial building where a space-heating boiler (either steam or hot water) is installed and where hot water must be supplied during the summer months. It is not limited to any size apartment house.

Company surveys show that the use of large size coal costing about $24 a ton to supply domestic hot water was quite common and usually that the large space-heating boiler was fired with Buckwheat coal costing about $14 a ton. The use of a generator hook-up, therefore, makes it possible to use a fuel costing about 40% less for hot water during the winter months. This saving, in addition to the expected higher efficiency resulting from the elimination of the standby factor of the second boiler, probably results in a total decrease in wintertime fuel cost of 50 to 60%. This saving is even more pronounced when No. 6 oil is used in the large boiler. The efficiency increase is even greater where the boiler supplies steam to coils immersed in a hot water tank. In such a case the boiler must be operated at steam pressure during the non-space heating season. The standby losses in this event are enormous as compared to the relatively small amounts of hot water supplied, since they are already large even if 160F water should be maintained in the large boiler.

The advantages are as follows:

(1) Use of lower price fuel during winter months.

(2) During the summer months, with the small immersion coil boiler in operation, a substantially high efficiency can be expected because of the elimination of the use of a greatly oversized heating boiler and large storage tank with its attendant standby losses and maintenance costs. The availability of an off-peak gas rate greatly enhances the possibility of the generator hook-up.

(3) Complete shut-down of the large space-heating boiler and burner is possible during the summer months. This is of particular interest to those using heavy fuel oil with its sometimes troublesome operation during the summer when high boiler water temperatures are not available as during winter months when steam pressure is constantly maintained. In many instances operators of such oil burners mix a light and more expensive fuel oil with the heavy fuel oil to partially overcome the problem of obtaining proper combustion.

Another advantage, sometimes important, results from the much lower temperature in the boiler room, that avoids overheating the floor above during summer season.

(4) Use of a large Btu input to do a relatively small water heating job will result in a short on-operation of the burner. These short operations are inefficient since the combustion chamber is not up to incandescence during a good part of the short on-period, if at all. Oil burns best in a hot combustion chamber.

(5) The combination of the additional hot water stored in the small boiler and the active circulation of water within the space-heating boiler caused by the action of the booster, makes it possible to obtain more output during severe cold weather when the combined space heating and hot water needs must be supplied. It is difficult to estimate this increase percentage-wise since the increased heat transfer resulting from this active circulation is not known. It is obvious that, if necessary, the small boiler could be put into operation on the relatively few severe days which are encountered during the winter season, thereby taking the water heating load off the space-heating boiler. The space-heating boiler capacity is often in question when the heating contractor must decide whether the existing space-heating boiler is adequate to supply hot water. Often, this decision must be made when the building owner wants a quotation on the installation of an immersion coil to replace his antiquated water heater and storage tank.

(6) There is a substantial savings in space particularly when large hot water storage tanks are used.

Principles of Immersion Coil Water Heating

It is interesting to briefly consider the reason that this surprisingly small boiler, only 20½ inches wide, 40 inches high and 34 inches deep, can provide adequate hot water to serve up to about 18 families in an apartment house. This is particularly interesting, for it is customary to install a 350- or 400-gallon hot water storage tank for this size building. The over-all dimension of this gas designed boiler is only a fraction of the size of the storage tank without the hot water boiler to which it must be connected.

Tests run by Brooklyn Union have shown that this is made possible because the Viking boiler is especially designed to extract the heat from the hot boiler water quickly enough to take care of momentary peaks. This is attributed to the novel design of the boiler which produces an active circulation of water over the copper immersion coils. During the winter months, circulation is supplied by the booster pump. The removable

(Continued on page 126)

Welding Pipe and Tubes of Nickel and High-Nickel Alloy

Discussion of approved methods for welding pipe and seamless tubes fabricated of nickel and high-nickel alloy. Article also covers brazing techniques. Data supplied through the cooperation of International Nickel Co.

PIPE and tubes of nickel and high-nickel alloys are used for pipe lines, condenser and evaporator tubes, and for heating and ventilating coils in a number of industries. How to join such pipes and tubes through the various welding methods or through brazing calls for a knowledge of accepted procedures.

This article refers specifically to seamless tube which has been processed under controlled conditions. It does not include welded tube, welded and drawn tube, and large size, cold-drawn seamless tube. The metals covered are nickel and the high-nickel alloys Monel and Inconel. Pipe and tube of these metals are readily joined to themselves or to headers, flanges and fittings by the processes listed in Table 1. Also included in this table are the recommendations for filter materials, fluxes, and some application limitations.

Surface Preparation

Before starting to weld or heat the pipe or tubes for bending, all foreign material must be removed, such as grease, oil, lubricants, paint, marking crayons, or (in the case of used material) processing chemicals.

Sulfur or lead has an embrittling effect on nickel and

TABLE 1—WELDING PROCESSES AND MATERIALS.

Process	Material to Use With				Applications
	Monel	K Monel	Nickel	Inconel	
Metal arc welding electrodes[1]	130X	134[3]	131	132	For welding larger (over 2 inch O.D.) and heavier walled (above 0.125 inch) pipe and tube.
	140		141		For joining high nickel alloy to steel or other ferrous alloys.
Oxy-acetylene gas welding rods[2]	40	44	41	42	For welding all wall thicknesses on 2 inch O.D. and smaller or lighter than 0.125 inch wall in 2 inch O.D. and larger.
Flux	Inco 3	Inco 2[4]	None Req.	Inco 2	
Inert gas metal arc welding rods	60	64	61	62	For all wall thicknesses and all sizes of pipe and tube.
Silver brazing: Alloy[5,6]	Conforming to A.M.S. 4770H or Navy Spec. 47S13 (Int.) Grades IV or V.				For use under 450F where the fluid or gas being handled will permit use of a silver brazing alloy.
Flux	Conforming to A.M.S. 3410B or Navy Spec. 51F4.				
Copper brazing: Alloy	Copper None Req.	Copper None Req.	Copper None Req.	Copper Copper Plate or Nickel	For furnace brazing in a controlled reducing atmosphere and where the fluid or gas being handled will permit use of copper.
Flux					
Soft soldering: Alloy	Any usual soft solder composition				For use where the fluid or gas being handled will permit use of a soft solder and where strength requirements are very low.
Flux	Killed acid or proprietary flux	Killed acid or proprietary flux	Killed acid or proprietary flux	Strong proprietary flux for use with chrome bearing alloys	

NOTES

[1]Direct current—reverse polarity.

[2]Higher melting point brazing alloys may be used if they do not contain phosphorus.

[3]130X Monel electrode may be used if maximum response to age-hardening is not required in weld.

[4]One part lithium fluoride to two parts Inco 2 or 3 flux recommended.

[5]Grade III or similar phosphorus-containing alloys must not be used.

[6]Cadmium-free alloys are recommended for certain joints (See text).

the high-nickel alloys at temperatures over 600F, and either, or both, are likely to be present in the foreign materials. Heavy layers of oxide should be removed, as they can cause difficulty in the welding operation.

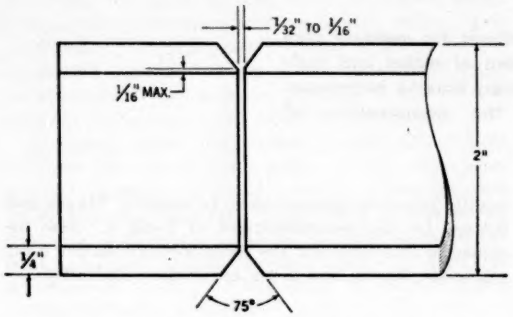


Fig. 1. Joint preparation for metal arc welding.

Metal Arc Welding

Metal arc welding is generally limited to the larger sizes and heavier wall thickness. Pipe or tubes over 2-inch O. D. with wall thickness over 0.125 inch may be arc-welded. No joint preparation is required for wall thickness through 0.093 inch, but beveling to a 75 deg included angle, Fig. 1, is recommended for heavier wall pipe and tube. A 1/32 to 1/16 inch-square land should be left at the root to facilitate set-up. A U-groove may be used to advantage for extra or double extra heavy pipe with 3/8 inch or greater wall thickness.

Joint spacing should be sufficient to permit complete, uniform penetration, but in no case should the sections be butted tightly before tack-welding. Enough gap should be left between the parts to allow for contraction of the tackwelds. If the parts are butted tightly, the shrinkage of the tackwelds will create compressive force in the joint and cause incomplete or erratic penetration. Backing rings are not recommended since they tend to become stress raisers and provide focal points (crevices) for corrosion. The welding sequence shown in Table 3 also may be used for metal arc welding of joints in the vertical position.

No preheat is required unless the ambient temperature is freezing or below, and then the joint need only be warmed to about 75-100F. All welding slag should be removed from each bead before the next bead is deposited. Normally, stress-relieving of welds is not done unless required by some governing code or specification.

Welding Castings

Castings of these metals are welded to themselves or to wrought, high-nickel alloy fittings or pipe. It is necessary to remove the casting skin, either by mechanical (grinding or machining) or chemical (pickling) means. Neither preheat nor postheat is required. It is essential that orders for cast nickel, Monel or Inconel fittings bear the notation "supply welding grade." Precautions noted previously regarding surface preparation should be observed.

Oxy-acetylene Welding

While the oxy-acetylene process may be used for welding all pipe and tube, it is especially recommended where the wall thickness is considered too light for metal arc welding or where the diameter is less than 2 inches.

Use of tank or bottled acetylene is recommended for the welding or silver brazing of nickel and high-nickel alloys. Shop generated acetylene should not be used for this purpose unless a scrubbing unit is available to remove sulfur from the gas.

The flame should be adjusted to a slightly reducing condition. The amount of excess acetylene should only be sufficient to compensate for the normal regulator fluctuation and to eliminate possibility of the flame becoming oxidizing in nature. When it is necessary to use an excess acetylene flame longer than 1/16 inch to balance regulator fluctuation, the regulators should be overhauled.

The joint preparation and design for oxy-acetylene welding is shown in Fig. 2. Precautions outlined under surface preparation should be observed before assembly of the joints.

The recommended fluxes and filler materials are shown in Table 1.

The proper welding tip size is best determined by experience, although the same or one size larger than that used for steel of similar thickness will usually be satisfactory. Avoid "puddling" the weld. Excessive agitation of the weld puddle can result in porous or cracked welds, for Monel and Inconel are quite fluid when molten, and nickel is relatively sluggish.

Complete penetration is desirable, as any unfused areas can, in some cases, result in early failure through

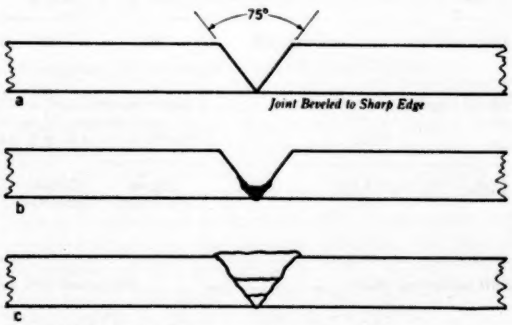


Fig. 2. Welding joint preparation showing layer build-up.

accelerated corrosion or fatigue. The use of two beads or layers is recommended for all diameters and wall thicknesses. The first bead should be made from the top (12 o'clock) to the bottom (6 o'clock) in the case of fixed position vertical welds. If the pipe or tube ends are square and the proper fitup and joint prepa-

ration, Fig. 2a, has been made, then no filler metal need be added for the first bead. The edges of the joint are flowed together to obtain complete penetration as in Fig. 2b. The second or successive beads, Fig. 2c, should be applied in a normal manner from bottom to top, using the proper filler wire. The two-bead procedure is equally effective when used on joints that can be rotated.

Fig. 3 shows four suggested joints for welding tubes into tube sheets.

Inert Gas Metal Arc Welding

Inert gas metal arc welding may be used for joining all sizes and wall thicknesses of nickel and high-nickel alloy pipe and tube. It is particularly well suited to the welding of thin-wall tube joints in the pipe shop, where the joint can be rotated during welding. Moderate air movement in the shop, due to fans or welding generators, or in the open (wind) may disrupt the protective inert gas blanket around the arc and cause porous welds. When these conditions are present, the oxy-acetylene process is more generally practical and economical.

The joint preparation, Fig. 1 and 2, and need for cleaning are the same as those required for other welding processes. The choice of joint preparation is governed by the diameter and wall thickness. High-purity welding grades of helium or argon should be used as a shielding gas, although helium will usually insure better weld soundness. Adequate gas flow must be maintained. Gas flow less than 10 cfh can offer inadequate protection and subsequent porosity.

While alternating current with superimposed high frequency can be used, greater soundness and ease of handling will be obtained with direct current-straight polarity. The 60 series filler wires should

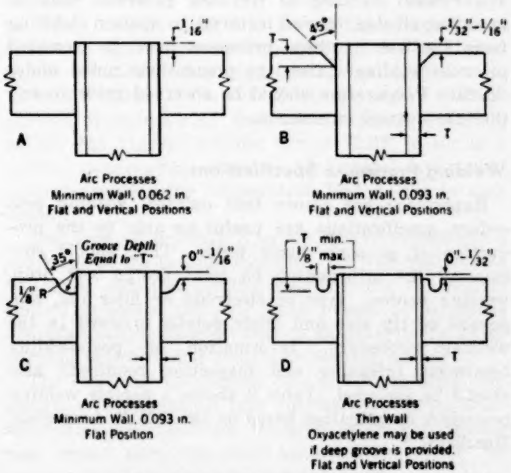


Fig. 3. Suggested joints for welding tubes into tube sheets.

TABLE 2—GENERAL WELDING PROCEDURE.

Base metal	Monel—A.S.T. M. Spec. B165	
Process	Metal Arc	Oxy-acetylene (Note A)
Filler material	130X Monel	40 Monel
Flux	-------	Inco 3
Power	DC Rev. Pol.	-------
Backing	None	None
Preheat	None	None
Postheat	None	None
Welding position	Pipe horizontal—joint vertical	

Note A—Flame shall be slightly reducing (1/16 inch excess acetylene feather).

be used where the need for filler metal is indicated, see Table 1. These wires will provide welds having mechanical and corrosion-resistant properties comparable to those of the base metal. They are especially suited for the production of sound welds and should be used when the welding is to be done with manual equipment.

Welding should progress steadily without puddling or agitating the molten pool. A short arc should be maintained at all times, as the weld soundness will decrease as the arc length approaches or exceeds 1/16 inch in length.

Where service conditions require the elimination or removal of all flux from the completed joint, the inert gas metal arc welding process is preferred to the oxy-acetylene or metal arc processes.

Silver Brazing

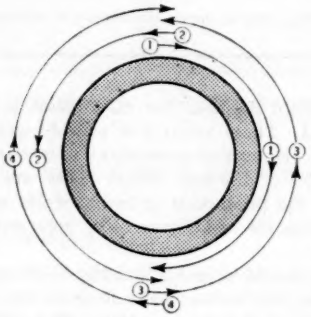
Silver brazing is useful for joining all sizes of pipe and tube where the corrosive environment and service temperature will permit the use of a silver-brazing alloy. The strength of silver-brazed joints in nickel and high-nickel alloys drops off sharply above 450F.

Lap or socket-type joints are recommended, and the amount of lap should be at least 3 to 5 times the wall thickness of the thinnest member. The fit of parts is important, and the clearance, for the brazing alloy to flow through, should be held to a minimum. When radial clearances over 0.005 inch to 0.006 inch are permitted, the strength of the joint will only be that of the brazing alloy, or approximately 50,000 lb per sq in. Maximum joint strengths are obtained with approximately 0.002 inch radial clearance, but clearances of this order are rather difficult to obtain in production in pipe and tubing joints.

Standard brazing fittings, valves, elbows, reducers and other shapes are available. The brazing alloy may be hand fed into the joint or preplaced in the form of rings or other wire forms or as foil. Any phosphorus-free silver-brazing alloy can be used on nickel and high-nickel alloys. However, a low-melting temperature alloy such as those conforming to U. S. Navy Spec. 47S13 (Int.), Grade IV, or A.M.S. Spec. 4770A is recommended to reduce oxidation or warpage during brazing.

TABLE 3—DETAILS OF WELDING PROCEDURE.

Pass No.	Metal Arc		Oxy-acetylene	
	Electrode Diameter Inch	Current Range Amp.	Filler Rod Diameter Inch	Tip Size
1	1/8	85-95	Note A	4
2	1/8	85-95	Note A	4
3	1/8	80-90	3/32	4
4	1/8	80-95	3/32	4



Note A—No filler required on Passes No. 1 and 2. Base metal to be fused to full depth of square land.

Where stress cracking is encountered with these alloys and the stress cannot be removed, a cadmium-free brazing alloy is recommended. Stress can occur from cold work in the material, applied force during brazing, or from differential thermal expansion caused by rapid heating.

The joints must be free of oxide and all foreign material, and the cleaning operation should preferably be done just before assembly of the parts. All pieces should be fluxed liberally, both male and female, and assembled immediately. More flux is then applied to the exterior of the joint.

A moderately reducing oxy-acetylene flame should be used. The flux will serve as an indicator of temperature as it becomes a clear fluid at approximately 1,000F. When the joint has been uniformly heated to the temperature where the flux is water-thin, a drop of the brazing alloy should be melted onto the joint and the heating continued until this drop wets out smartly; maintain the heat at this approximate temperature and complete application of the brazing alloy. Use the flame as a brush, and brush the heat into the joint. The flame as brush should be kept in motion to avoid localized overheating. Remove residual flux, both inside and outside, with boiling water.

Copper Brazing

Copper brazing may be used to join assemblies of tube and pipe where the corrosive medium will permit the use of copper. Since copper brazing is done in a controlled atmosphere furnace, assemblies must be of such size and shape that they will fit into an available furnace. Copper brazing requires close control of clearances. A light press fit to an 0.002 inch gap on a side is the limit for successful brazing.

The chromium content of Inconel will cause difficulty in copper brazing. Therefore, Inconel parts are frequently given a copper plating. The copper plate is sometimes sufficient to supply the copper required to braze the joint. A bronze brazing flux may be required in some cases for Inconel in addition to the copper plating.

Soft Soldering

Soft soldering is sometimes useful for making pipe and tubing joints where the corrosive medium will permit and where the operating temperature is not above 212F. Joints made with soft solder are weak at their best, and lose their strength rapidly as the temperature is raised. Careful attention must be given to support of soft soldered joints. They should not be expected to carry any of the service or line load.

A pre-tinned lap or socket-type joint is recommended, with the lap being 8 to 10 times the thickness of the thinner member. Pre-cleaning, as in silver brazing, is essential for satisfactory soft soldered joints. Any good soft solder composition is usable, though the higher tin content solders are to be preferred. While killed acid or a proprietary flux may be used with nickel or monel, rosin or rosin-alcohol mixtures are unsuited. Inconel requires a strong flux to remove the chrome oxide. Proprietary fluxes recommended for chromium bearing materials should be used with inconel.

Thermal Cutting

Neither nickel, monel or inconel can be cut with conventional oxy-acetylene equipment. Mechanical separation with saws or friction wheels is preferred. The Powder Cutting[1] or Oxy-Arc[2] processes may be used, but all slag, burned material, or spatter resulting from the use of these processes must be removed prior to welding. Also, the precautions noted under Surface Preparation should be observed prior to any thermal cutting operations.

Welding Procedure Specifications

Experience has shown that detailed welding procedure specifications are useful as aids to the production of properly made welds. They should contain all the information on joint design and fitup, welding process, type of electrode or filler rod, amperage or tip size and other details involved in the welding procedure. Information on post-welding treatment (cleaning and inspection required) also should be included. Table 2 shows a sample welding procedure specification based on the A.W.S. Inspection Handbook.*

[1]Linde Air Products Company—patented process.

[2]Arcos Corporation—patented process.

*Reference should be made to the A.W.S. Welding Handbook, pages 1505-1506, and the Inspection Handbook for Manual Metal-Arc Welding for more complete procedure specification forms.

Individual Apartment Heating Control

LLOYD JOHNSON

Minneapolis-Honeywell Regulator Co.

Increasing demand for competitive plus-features in apartment dwellings has brought physical comfort increasingly into the consciousness of owner and tenant alike. Rising fuel costs, too, have created insistent demand for heating systems which will avoid the dumping of waste bulk heat out the windows of the more athletic tenants while their sedentary neighbors and the mothers of infants are clamoring for more heat. Individual apartment control, simple in design and operation, can provide maximum comfort for every tenant while actually operating the building on a minimum fuel budget.

MULTIPLE dwellings, especially in defense areas, will be among the least curtailed of building types during the present emergency, according to Washington estimates. Buildings committed in 1950 will proceed, and plans of the Public Housing Administration for defense housing will add a considerable volume in this classification. With present methods of financing under Section 608, costs must be contained within prescribed limits. Personalized heating, then, will be one of the most effective means of bridging the gap between allowable expenditure and the demand for competitive features.

Even assuming that a single controller could maintain a reasonably uniform temperature throughout the building, there is no such temperature that would establish comfort conditions for all the occupants. A survey of apartment dwellers throughout the United States revealed the following temperature preferences: 74 to 76F (10%), 71 to 73F (80%), 68 to 70F (10%). Instead of maintaining the entire building at 76F to satisfy the highest demand (or at 72.2F to strike a rather meaningless average), individual apartment control provides the temperature best suited to each tenant.

Any type of multiple housing structure presents a challenge to the heating engineer. No two apartments will have identical heating requirements. Individual control presents the only sure means of attaining equitable distribution of heat to all apartments under varying exposure and occupancy heating loads.

The relatively economical two- and three-story construction of the garden type apartment, with its characteristic open planning, while it offers the builder and renter alike the best opportunities under the present market, presents definite heating problems. Long, rambling structures, varying exposure, and long supply runs are common handicaps to heating such a project.

With individual apartment heat control each rental unit has its individual branch supply main. A thermostat located in the apartment operates a control valve which meters flow of the heating medium through that branch main. The apartment is consistently maintained at the desired temperature level. This prevents over-heating of the units closest to the boiler room, and under-heating of those farthest away. Tenants on short supply runs do not have to open windows and waste heat in order to be comfortable. This results in substantial fuel savings for the building owner. As a further protection against heat waste, apartment thermostats are available with a maximum temperature setting of 76F, thus preventing an excessive heat demand from any one unit. Both electric and pneumatic systems are applicable to personalized heat control.

Forced Hot Water

Hot water heating systems are well adapted to individual apartment heating control. The piping layout can be arranged so that only one thermostat and one valve is required per apartment. Little or no extra piping is needed.

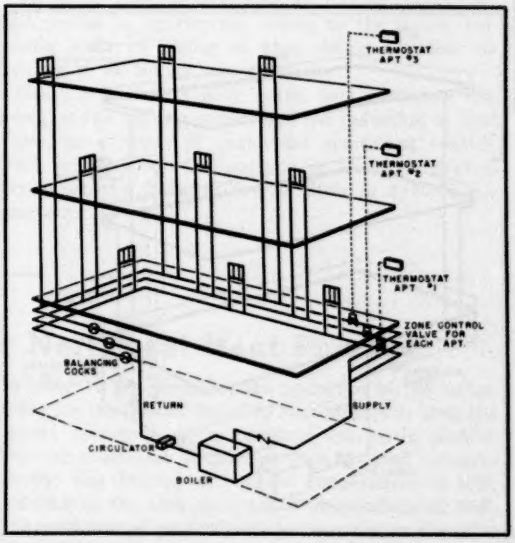


Fig. 1. Forced hot water loop system, a one-pipe system with branch mains looped around basement of the building. Each apartment or zone has an individual loop. Mono-flow fittings for radiators are installed at point where supply risers tee off the loops.

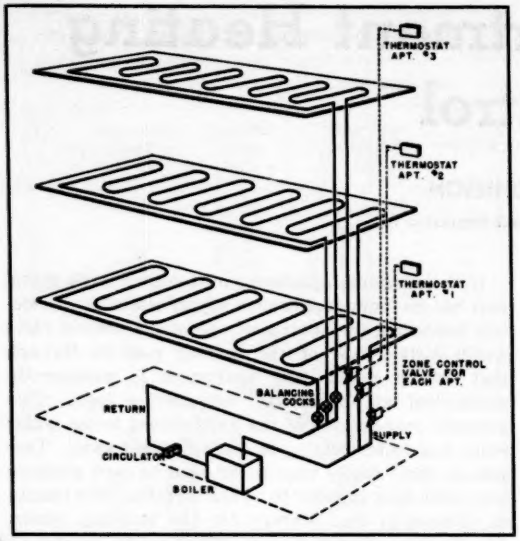


Fig. 2. Panel heating system, where panels may be located in the floor as shown or in the ceiling or walls. Each zone has its own supply and return system.

Temperature of the heating medium can be varied according to outdoor temperature by means of a single outdoor thermostat for the whole system. The outdoor control continually resets the control point of the heating medium by positioning a three-way mixing valve. The three-way mixing valve regulates water temperature to the heating system by proportioning the heated water from the boiler and cooler water which is by-passed from the return. The circulating pump operates continuously, as long as the outdoor control indicates a need for heat.

The loop or circuit system used with radiators or convectors, Fig. 1, has many advantages over other piping arrangements. All main pipe lines are in the basement in loops. There are no lateral piping runs in the room spaces. Installation is simple. In the loop system only one valve and one thermostat are required per apartment. The valve regulates the flow of hot water to each loop and thus controls the heat to the apartment.

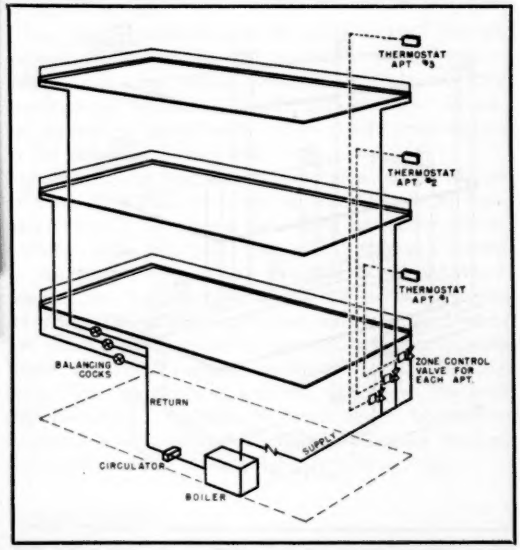


Fig. 3. Forced hot water baseboard system, with baseboard radiation installed around all outside walls. Additional radiation may be placed on inside walls. A separate supply and return system serves each zone.

Panel Heating

If radiant panel heating is planned, individual apartment heating control, Fig. 2, becomes essential to protect against excessive lag and overshooting. Considering the increased efficiency of the system and refinement of control which it affords, the added cost for controls is negligible. Here again one thermostat and valve per apartment will do the job, and a separate control system for the boiler, including an outside thermostat, varies the supply water temperature ac-

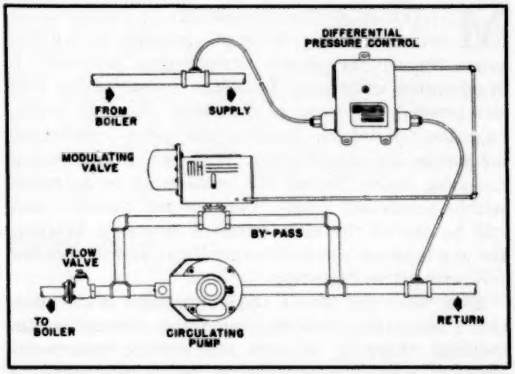


Fig. 4a. Hook-up for modulating control valve on by-pass around circulator to maintain constant pressure differential from supply to return.

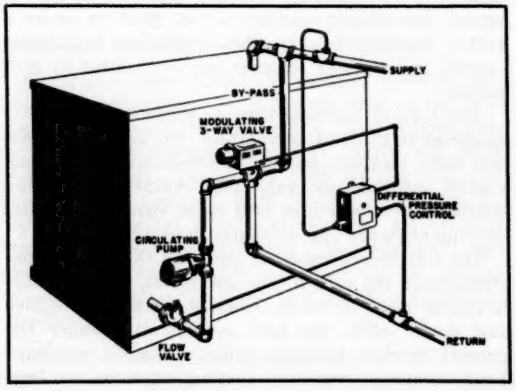


Fig. 4b. Alternate hook-up with pressure control actuating 3-way mixing valve.

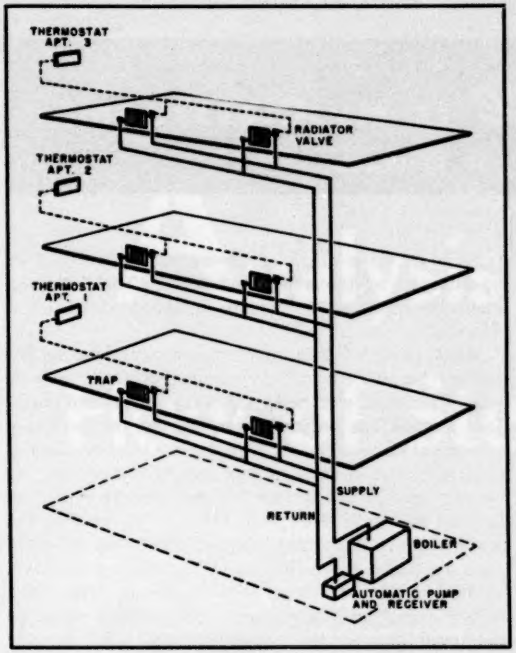


Fig. 5. Two-pipe steam system using a radiator control valve to meter heat to each radiator according to requirements of the thermostat. Several radiator control valves may be operated by a single thermostat.

cording to the weather. This system may be used with either floor, ceiling, or wall panels.

The piping arrangement recommended with baseboard heating is shown in Fig. 3. As with other systems, one thermostat and one valve per apartment are required. The valve may be located either in the basement as shown or at the apartment level. A separate control system for the boiler, including outside thermostat and mixing valve, varies the supply water temperature to meet the weather requirements. Either radiant or convection types of baseboard units may be used.

Two methods of utilizing a by-pass with a modulating control valve to maintain a constant pressure differential between the supply and return on a forced hot water system are shown in Fig. 4. These arrangements avoid the building up of excessive pressure when most valves in the system are closed. Except where space limitations would prevent its use, the simpler hook-up (Fig. 4a) with the by-pass around the circulating pump is preferable.

Because of its relatively high temperature, steam must be controlled carefully to insure uniform apartment heating. With the individual apartment control system, a control valve is applied to each radiator or convector as shown in Fig. 5. One or more thermostats may be used in each apartment according to layout and exposure. Each thermostat operates as many radiator valves as desired to supply steam as needed.

Night Shut-Down

Automatic day-night control of the entire heating system is another fuel-saving measure that can be incorporated into any multiple housing installation. Here is a typical sequence on a forced hot water system: (1) At 11 p.m. or 12 p.m., a time switch cuts off the individual apartment control. Individual radiator valves or zone valves to each of the apartments assume a fully open position. (2) A night thermostat, located in a fairly representative location in the building (preferably on the north side) maintains indoor temperature at 60 or 65F. (3) While the night system is in control, a time relay operates the circulating pump for a five-minute period, at half-hour intervals —independently of heat demands from the night thermostat. (4) At 5 a.m. or 6 a.m. the time switch automatically reverts control to the individual apartment thermostats, permitting heat to be restored to the desired day-time setting by the time tenants normally arise.

To avoid possible over-heating during night setback period in apartments closest to the boiler, balancing cocks or sizing of pipe should equalize resistance to all branch supply mains.

Heating engineers have found that increased efficiency of the heating system and the reduction of heat waste, as a result of individual apartment control, often accounts for fuel savings of 20%. Individual control can be installed for as little as $100.00 per apartment.

High Efficiency Reported For Northwest Heat Pumps

High coefficients of performance were reported in Portland, Ore., for the heat pump installation, one of the largest in the world, which operates the complete air conditioning system in the Oregonian Building, housing the newspaper plant and offices of the Portland *Oregonian*. The report was made July 4 at the semi-annual meeting of ASHVE in the Hotel Multnomah, by three Portland engineers.

They are J. Donald Kroeker, consulting engineer; John H. Bonebrake, of Mr. Kroeker's office, and James A. Melvin, chief operating engineer of the Oregonian Building. They described the operation of the installation for the bulk of the 1949 heating season with the system operating under complete automatic control. The net coefficient of performance, figured conservatively, was 10.2 at an outdoor temperature of 30F, and 20.8 at the average outdoor temperature of 49F. The coefficient of performance is computed as the ratio of the total heat used in heating the building and in heating the air going into it as related to the total electrical energy used by the system in producing that heat.

Experience is my Classroom

By T. W. REYNOLDS

EDITOR'S NOTE. Mr. Reynolds continues the subject of servicing, trouble jobs, maintenance and similar problems.

SPACE AND FACILITIES FOR SERVICE

Strainers are less frequently cleaned today than formerly, even when they are readily accessible. As a rule, strainers, gages, thermometers and other devices needed for operation and servicing are more and more crowded in, since space is costly today. They are quite apt to be left to themselves, even though reported as read or serviced. A minor employee will simply record on the daily log some reading which he has learned is close to the usual. When the unusual happens no one is prepared.

Men are no longer inclined to work under uncomfortable conditions, particularly when they are service men meeting these same conditions day in and out. We are all looking at inconveniences as a thing not necessary in these times. We are looking for comfort, and rightly so. At its best, the servicing of equipment is not a very interesting job, and certainly devoid of all interest when dirty and confined in a poorly lighted, under-ventilated and overheated place.

Facilities should also be provided for servicing the larger equipment out in the open areas. Such equipment may have the appearance of less crowding, but there must be openings and space left for getting equipment or its larger parts in and out of the area and there must be room to pull tubes. Block and tackle should be provided overhead and attached to structural steel sufficiently strong to take the weight of parts removed. Convenient floor drains should also be provided to take the spill of water or other liquids as parts are drained in removal. Finally, all indicating instruments should be well lighted and located for convenient reading. Portable ladders will seldom be used for this purpose. Even a fixed ladder should be installed only when other means are unavoidable. Valve operating chains reached from the floor should not be forgotten.

LOW VOLTAGE AND COOLING TOWERS

Cooling towers have still other troubles. Their fans may be shipped from the factory with the pitch of blades not correct for producing the required amount of air to perform the cooling required. Then someone changes the pitch on the job to his way of thinking and the fan motors get overloaded, or there is too little pitch. If the change in pitch is made in the warmer weather, the fans will be handling lighter air per cubic foot, but later as the weather becomes colder the required fan horsepower will go up, and the motors may become overloaded and overheat. However, if the fan motors were previously oversize, there should be no difficulty as the weather changes. The foregoing incidents occurred on a job in the heat of lower Florida.

Many parts of this country are experiencing low voltage because the utility companies are unable to supply sufficient electricity for today's expanded needs. Low voltage has become a problem for motor-driven equipment on many a job. A particular locality supplies electricity at 208 volts, so you specify motors (say at cooling tower fans) for the voltage. On later check you find the motors in place with 220 volts stamped on the name plates. The manufacturer says they are 220 volts in name only, and are 208 volts as specified, because NEMA standards allow a plus or minus 10% voltage variation. This means that 198 volts would be the lower limit for the motors and well below the 208 volts specified. All this is very nice, but had the manufacturer furnished 208-volt motors, they would, at the usual 10% variation, have been good for 187 volts. This, you find, is just about the actual voltage received at certain times, due to temporary overloading of the local utility's main transmission line, or inadequacy of the transformers supplying the entire building.

Low voltage causes an increase in current at the cooling tower fan motors, and therefore has the same effect as installing heater elements which are too small in the circuit-breakers protecting the motors. The circuit-breakers then do their normal protection service and trip to stop the fan motors just when you have greatest need for cooling tower operation. You reset the circuit-breakers to start the fans again, but the residual heat in the parts immediately adjacent to the heater, plus the additional heat caused by the inrush of current in starting, is so great that the breakers trip again. It is then necessary to wait a considerable length of time for the circuit-breakers thoroughly to cool before the fans can be restarted.

Meanwhile, you get annoyed by further difficulties because you cannot tell when the cooling tower fans have stopped, except by watching the water curtain. This is due to warning lights at the interlocking panel which are incorrectly wired to indicate that the fans are running, although they are actually stopped.

Sometimes the remedy for circuit-breaker action as described is to use the next size of heater coils. Such size may not allow current high enough to cause damage to the motors, yet be sufficient for any ordinary momentary drop in voltage without tripping the circuit-breakers.

(The question of servicing will be continued in this department in a subsequent issue.)

Analysis of Data on Flow of Steam in Pipes

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With New Working Charts for Pipe Sizing

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Design data for steam flow in pipes has been standardized to such an extent during the past quarter century that the same empirical equations and flow tables appear and reappear in reference sources. Since the original data and the basic assumptions were presented during the last century, a re-examination of the flow equations seems appropriate even if somewhat overdue. The basic objective of this analysis was to determine whether the developments in fluid flow theory during recent years did not require a revision in the working tables and equations as applied to steam flow.

IN the first part of the century when the science of the flow of fluids consisted largely of an accumulation of empirical equations applicable to a fixed set of conditions, the flow equations served a limited but nevertheless practical purpose. An extrapolation of the equations to conditions that did not differ too widely from those of the original experiments could be justified, and probably did not result in extreme oversizing or undersizing of the pipe lines. As is true of many empirical approaches, however, the original limitations were ignored and the data were extrapolated to conditions which were not applicable. In the case of steam flow this has happened to an absurd extent.

The discussion of steam flow has been divided into the following categories:

Part A. Historical development of the theory of steam flow in pipes. A step-by-step development of empirical steam flow equations is given, with emphasis placed on the most significant literature of the past 95 years.

Part B. Correlation of steam flow data with Moody chart. It will be shown that the so-called Babcock equation in common use is limited in its application to a narrow range of conditions.

Part C. The Page-Konzo working charts for sizing of pipes for steam flow. Revised steam flow charts are presented, which are based on a re-analysis of the available experimental evidence.

Appendix A. Evaluation of data on absolute viscosity of steam.

Appendix B. Consideration of factors affecting steam flow and pressure drop.

This discussion is analytical in approach and is based largely on an intensive search through literature. No new laboratory experiments or original data are presented. The two sets of references on steam flow and viscosity have been annotated, and an evaluation made of the many contributions.

Acknowledgments

This study was suggested during a conference with Professor Warren S. Harris of the Department of Mechanical Engineering of the University of Illinois. The preliminary groundwork for the analysis was developed by Kenneth L. Lamm, former graduate student. A major portion of the analysis was made by Robert H. Page, as a part of his graduate studies leading to the degree of Master of Science.

PART A.

HISTORICAL DEVELOPMENT OF THE THEORY OF STEAM FLOW IN PIPES.

The historical development of steam flow theory has not been easy to trace, since the developments were not of equal merit and were not originally presented in logical time sequence. The references presented in abstract form in Table 1 may be considered as a representative summary of the published material. A few references which do not deal specifically with steam flow have been included, either to trace the source of deductions made in steam flow literature, or to present the development of flow theory for all fluids.

a. Darcy-Weisbach Equation for Fluid Flow

The flow relationships that are in current use originated with Darcy (1)* and Weisbach (2), both of whom worked with flow of water. The Darcy-Weisbach equation for drop in pressure head for water flow has been carried forward to this time in its original form, as follows:

$$\triangle h = \frac{f\ L\ v^2}{D\ 2g} \qquad (1)$$

In terms of ft-lb-sec units, the terms are as follows:

$\triangle h$ = head loss in feet of fluid flowing,
f = friction factor (Darcy-Weisbach),
L = length of pipe in feet,
D = internal diameter of pipe in feet,

$\frac{v^2}{2g}$ = velocity head in feet of fluid flowing.

b. Unwin-Babcock Equation for Friction Factor

In 1857, Darcy (1) proposed that the friction factor, f, should be considered as a function of the diameter alone, in the form:

$$f = (\alpha + \beta/d) \qquad (2)$$

where α and β are constants, and d is the diameter in inches. In 1876, Unwin (4) modified the Darcy equation to the form:

$$f' = k\ (1 + 3.6/d) \qquad (3)$$

where f' is equal to $f/4$.

This equation is the same as that published by Babcock (8) some 14 years later, and which has been commonly referred to as the 'Babcock' equation. Since Babcock gave no derivation nor explanation of the equation, the authors are of the opinion that the proper reference to equation (3) should be the 'Unwin-Babcock' equation.

It is of interest to note that the equation was derived by Unwin for water flow and was adopted by Babcock for steam flow. However, this practice of taking an equation determined for one fluid and applying it to some other fluid was common amongst early experimenters. The Babcock statement (7) that the "Diameter of mains leading from boiler to radiator surface should be equal in inches to 1/10 of the square root of the radiating surface, mains included, in square feet" was representative of the rule-of-thumb design procedures used in heating practice in 1885.

c. Evaluation of Constant k in Unwin-Babcock Equation

Unwin (4) in 1876 suggested a value of 0.0028 for the k term in equation (3) for air flow at a velocity of 100 fps. In 1894, Unwin (11) re-evaluated the constant and presented a value of 0.0027, based largely on his analysis of experiments made by Riedler and Gutermuth with air flow. This value for k of 0.0027 is still in common use after almost 60 years from the time it was first proposed. Incidentally, Unwin replaced the diameter term, D, in equation (1) by the hydraulic radius, m, but made no other changes. Thus, the numerical value of the Unwin f' term is one-fourth of that for the Darcy-Weisbach f term.

One of the significant experiments of this era was made by Carpenter and Sickles (17) on steam flow. They were able to confirm the k value of 0.0027, *only by discarding extreme values.* No good reason was given for discarding part of the data. The original data of Carpenter and Sickles will be referred to later in Part B of this discussion. Green and Stratford (14) and McRae (15) also reported experimental results with steam flow and were not successful in confirming the k value of 0.0027. However, since their reports were not widely circulated, any influence they might have had in questioning the Unwin constant was negligible in effect.

By the turn of the century, both the Unwin-Babcock equation and the Unwin constant had become well established and to some extent 'frozen.' For example, an interesting summary made by Gebhardt (24) in 1909 shows not only that the Unwin-Babcock equation was widely accepted, but that the only other recognized form for friction factor was one in which f was assumed to be a constant and not a function of diameter.

d. Derivation of Unwin-Babcock Equation

The equation for steam flow rate, in pounds per minute, was derived from a modification of equation (1), as follows:

$$\text{Since,} \qquad 144\ P = \rho\ \triangle h \qquad (4)$$

where P is the pressure drop in pounds per square inch, and ρ is the density of steam in pounds per cubic foot

$$\text{and also since,} \qquad v = \frac{144\ W}{60\ \rho\ (\pi d^2/4)} \qquad (5)$$

where W is the steam flow rate in pounds per minute, the substitution of equations (4) and (5) in equation (1), resulted in an equation of the following form:

$$P = \frac{C_1\ W^2\ L}{\rho\ d^5}\left(1 + \frac{3.6}{d}\right) \qquad (6)$$

where $C_1 = k\ (0.04839)$

Equation (6) is still in common use at the present time.

During the early part of the present century, numerous writers extended the application of equation (6) over a wide range of conditions without regard for the limitations of the empirical constants. For example, Carpenter (27, 28) in 1912 extended the equations to pipe sizes ranging from 1 inch to 60 inches in diameter, and to steam pressures ranging from 0.4 inch of mercury to 500 psi. Such extensions of the equation are highly questionable.

*Numbers refer to references in Table 1.

e. Reynolds Number–Friction Factor Correlation

Although steam flow theory had attained a static stage in development by 1910, significant progress was being made in the theory of fluid flow in general. One of the early attempts to show that the friction factor was dependent upon some variable other than diameter alone was made by Blasius (26) in 1912. It is true that previous investigators had given some indication that variables other than diameter were influencing the magnitudes of the friction factor. For example, Darcy (1) in 1857 mentioned the effects of velocity as well as the degree of roughness of the surface of the pipe. Also, Unwin (22) in 1907 indicated that the friction factor was affected by temperature, and thus the viscosity of the fluid. For some strange reason, however, in the case of steam flow the restricted Unwin-Babcock concept persisted to such an extent that little work was done to correlate the existing experimental evidence with the newer concepts of flow.

Referring again to 1912, Blasius made a recalculation of the data obtained by two other experimenters with water flow and showed that the factor f in the Darcy-Weisbach equation was a function of $\frac{vD\rho}{\mu}$, where μ is the absolute viscosity of the fluid. This dimensionless expression is referred to as Reynolds number. Another significant contribution was that by Stanton and Pannel (29), who adopted Reynolds' theories (6) of 1883, and established experimentally that the friction factor for the flow of such diverse fluids as oil, water, and air was a function of Reynolds number.

In 1915, Lander (31) presented experimental results with steam flow and water flow on the diagram first suggested by Stanton and Pannel. This research can be considered as the first valid evidence that the friction factor for steam flow was a function of something other than diameter alone.

f. Modern Developments and the Moody Chart

Since 1914 the developments in fluid flow theory have been made at an accelerated rate. The contributions of Buckingham and Rayleigh in the field of dimensional analysis proved that the friction factor was a function of Reynolds number. In 1939, Keenan (57) obtained experimental results with water and steam, and showed that the friction factor was not only a function of Reynolds number, but was also the same for incompressible and compressible flow. A slight modification in the form of presentation of data was given by Rouse (59) in 1943, but essentially an agreement had been reached that friction factor was a function not of diameter alone, but of Reynolds number and the relative roughness of the pipe. As a final step in the development of fluid flow up to this time, Moody (62) in 1944 presented a convenient chart showing variations in friction factors for wide ranges of Reynolds number and for various values of the relative roughness of the pipe surface.

In view of the evidence presented in the publications listed in Table 1, it would appear that the time has come in steam flow practice to discard the older concepts of Unwin and Babcock, and to utilize the newer concepts. Part B of this discussion shows a correlation of some experimental results with the values given in the Moody chart. A comparison will also be shown of the friction factors as determined by the older and newer methods of analysis.

TABLE 1.—ABSTRACTS OF REFERENCES DEALING WITH FLOW OF STEAM IN PIPES.

No.	Date	Author	Fluid Used	Experimental Work	Reference Source
(1)	1857	H. Darcy	Water	Yes	Recherches Experimentales Relative Au Movement De L'Eau Dans Les Tuyaux.

Discusses previous experimenters' results on water flow. The frictional resistance varies considerably with the nature and degree of roughness of the surface of the pipe. The friction factor f varies with velocity and pipe diameter. Since there was not a wide variation of velocity in water mains, author recommended that velocity effects on f be disregarded in most practical calculations, and proposed: $f = \alpha + \frac{\beta}{d}$; where α and β are constants, and d is the pipe diameter in inches.

(2)	1870	J. Weisbach	Water	Yes	Flow of Water Through Pipes, pp. 863-869.

In water flow, the general form of drop in head is: $h = \frac{fl}{d}\frac{v^2}{2g}$ from experiments of Couplet, Bossut, and Du Buat. Previously, Prony, Eytelwein, and D'Aubuisson deduced that: $h = (\alpha + \beta v^2)\frac{l}{d}$ each giving different values for the constants α and β.

Author proposes: $h = \left(\alpha + \frac{\beta}{\sqrt{v}}\right)\frac{lv^2}{2g}$ where $f = \left(\alpha + \frac{\beta}{\sqrt{v}}\right)$

The works of four other investigators were reported, as follows:

M. de Saint Venant $h = \phi\ (V12/7)$
Woltman $h = \phi\ (V7/4)$
Eytelwein $h = \phi\ (V35/18)$

Darcy $f = \left(\alpha + \frac{\beta}{\sqrt{v}}\right)$ and $f = \alpha + \frac{\beta}{d}$; the latter being inaccurate for small velocities.

(3)	1871	Hawksley	Air Water	No	Proc. Inst. of C. E. v. 33, p. 55.

In discussion of paper on pneumatic tubes, author implies that f is a constant for air and water flow. Gives equation for velocity in terms of head loss, diameter, and length.

(4)	1876	Unwin	Water Air	Yes	Ency. Brit., 9th ed. v. 12, "Hydro-Mechanics," pp. 484, 508, 516.

Describes attempts of Prony, D'Aubuisson, Eytelwein, and Weisbach to correlate f for water in the form: $f = \alpha + \frac{\beta}{\phi(v)}$. Darcy is accredited with $f = k\left(1 + \frac{\beta}{d}\right)$, and f is not a function of v. Unwin concluded that f was a constant in the work of Culley and Sabine with flow of slightly moist air in lead pipes, 2¼ inches in diameter and in

No.	Date	Author	Fluid Used	Experimental Work	Reference Source

lengths from 2,000 ft to 6,000 ft. Unwin gives: $f = k_1\left(1 + \frac{3.6}{d}\right)$

Unwin suggests a k value of 0.0028 for air at 100 ft per sec. Stockalper (air flow at St. Gothard Tunnel) gives $f = k_2\left(1 + \frac{3.6}{d}\right)$, but the constant k_2 is about half that of the Unwin constant k_1.

(5) 1883 Briggs — Steam — No — Warming Buildings by Steam, Proc. Inst. of C. E., v. 61, p. 124.

Tables given for the internal diameter of steam supply mains for lengths up to 600 ft, at 10 psig and fixed pressure drops. Values based on constant f, proposed by Weisbach as an approximation.

(6) 1883 O. Reynolds — Water — Yes — Phil. Trans. of Roy. Soc. of London, v. 174, pp. 935-982.

Investigated change from "direct to sinuous" flow in pipes. Theoretical analysis and experimental evidence show birth of eddies in flow depended upon value of $\frac{v D \rho}{\mu}$, as did also the general character of fluid motion. From correlation with Darcy's experiments, author observed that the nature of the surface of the pipe had an effect on the resistance above the critical velocity. When values of Reynolds Number were identical, then identical pressure drops per unit length were observed.

(7) 1885 G. H. Babcock — Steam — No — ASME Trans. p. 859.

"Diameter of mains leading from boiler to radiator surface should be equal in inches to 1/10 of the square root of the radiating surface, mains included, in square feet."

(8) 1890 G. H. Babcock — Steam — No — Steam, Babcock and Wilcox Co., p. 89.

Following equation given for friction factor with no derivation or explanation: $f = k\left(1 + \frac{3.6}{d}\right)$.

(9) 1892 M. Ledoux — Air Steam — Yes — Annales Des Mines, v. 2, pp. 562-598.

A study of the pressure drop of compressed air and steam in pipes. The pipe diameters were 1.85 inches, 2.79 inches, and 3.94 inches, with lengths of 382 ft to 1,082 ft. Experiments by Gutermuth with 5.51-inches diameter pipes also noted. The pressure drop was evaluated by: $P_1^{1.94} - P_2^{1.94} = 0.1669\frac{w^2 L}{d^5}$.

(10) 1893 Geipel and Kilgour — Steam — Yes — London Electrician, May 5.

The friction factor was found to be a constant.

(11) 1894 W. C. Unwin — Air — No — Development and Transmission of Power, London.

Unwin obtained values for the coefficient of friction from experiments of Riedler and Gutermuth on compressed air mains in Paris, which were 11¾ inches in diameter and 10 miles long. Results agreed with: $f = 0.0027\left(1 + \frac{3.6}{d}\right)$.

(12) 1895 W. Cox — Steam — No — Amer. Mach., Feb., p. 171.

Author used the equation: $f = k\left(1 + \frac{3.6}{d}\right)$. However, author incorrectly states that the factor $\left(1 + \frac{3.6}{d}\right)$ is a variable coefficient, in order to compensate for pressure loss at entrance to pipe, and for the production of velocity.

(13) 1895 R. C. Carpenter — Steam — No — Heating and Ventilating Buildings, p. 224.

No.	Date	Author	Fluid Used	Experimental Work	Reference Source

Recommends sizes of heating returns which had proven satisfactory. Also recommends the use of a water formula, attributed to Briggs, for steam flow calculations.

(14) 1895 Green and Stratford — Steam — Yes — Thesis at Cornell Univ.

An attempt to evaluate the term k with 195 ft of 3-inch pipe, 112 ft of 2½-inch pipe, 115 ft of 2-inch pipe, and 25 ft of 8-inch pipe. Discarded some data in order to make k a constant.

(15) 1896 J. A. McRae — Steam — Yes — Thesis at Univ. of Ill. Flow of Steam Through Small Pipes.

An attempt to correlate Babcock's equation for pressure drops in ¾-inch, 1-inch, and 1¼-inch pipes for lengths of 49 ft and 100 ft. Some results were proportional, but attempted correlation was not realized.

(16) 1897 A. J. Martin — Steam Air — No — Engineering, v. 63, p. 361.

Gives charts mainly of Unwin-Babcock form for determining flow relations in pipes. Also determined a constant f from their equations. Mentions experiments of Riedler with compressed air mains in Paris.

(17) 1898 R. C. Carpenter & E. C. Sickles — Steam — Yes — Experiments on the Flow of Steam Through Pipes, ASME Trans. v. 20, p. 342.

Experiments made in attempt to evaluate k with 1-inch, 1½-inch, 2-inch, and 3-inch pipes which were 90 ft long, and with both covered and uncovered pipes. Authors state results of Eytelwein, Weisbach, Arson, and Unwin. Authors assumed that $f = k\left(1 + \frac{3.6}{d}\right)$ would be sufficient for all velocities. The experimental values for k varied considerably, so that extreme values were discarded, and the remaining values were averaged. Authors state that a k value obtained from a 12-hr boiler test in 1897 with a 3-inch pipe 95 ft long differed from the averaged k value by only 4%. Tables presented based on a k value of 0.0027. The k for air at St. Gothard tunnel was 0.0028, whereas the Arson value of k for air was 0.005. In the discussion, Carpenter reduces Ledoux's work to the Babcock formula.

(18) 1899 J. M. Allen — Steam — No — Locomotive, v. 20, p. 17.

Uses formula proposed by A. J. Martin, which is essentially the Babcock equation, to construct tables of pipe sizes for definite pressure drops.

(19) 1904 Gutermuth — Steam — Yes — Zeit. d. Ver. D. Ing., April

Friction factor determined to be a constant.

(20) 1907 J. A. Donnelly — Steam — No — Standard Sizes of Steam Mains, ASHVE Trans. v. 13, p. 43.

Changed formulas for water flow to apply to steam flow, and gives conversions for the formulas in existence.

(21) 1907 W. Kent — Steam — No — The Carrying Capacity of Pipes in Low Pressure Steam Heating, ASHVE Trans. v. 13, p. 54.

Tables for pipe sizing are developed assuming a drop of 1 lb per 1,000 ft. A variable coefficient from Darcy's work on water is introduced. Other tables are given for different pressure drops, corrected by the ratio of the square roots of the pressure drops.

(22) 1907 W. C. Unwin — Water — Yes — A Treatise on Hydraulics.

A discussion of previous experimenters' work with water. The conclusion is given that the pressure drop varies as the n-th power of the velocity. Values of n are presented for different pipe surfaces. It was also observed that the frictional resistance diminished as the temperature increased. Unwin reasoned from experimentally established relations with water, and stated that the pressure loss in terms of head of fluid flowing was proportional to the velocity head, length, and the reciprocal of the hydraulic radius. The f value was given as a coefficient of proportion. Darcy's fundamental relation: $f = k\left(1 + \frac{\beta}{d}\right)$ agrees fairly closely with the results of the experimenters.

No.	Date	Author	Fluid Used	Experimental Work	Reference Source

(23) 1908 Eberle — Steam — Yes — Z. V. D. I., v. 52, p. 664.

Author states f is independent of pipe diameter, steam pressure, quality, and velocity for a certain range. Pressures varied from three to 10 atmospheres with saturated and superheated steam in pipes up to six inches in diameter. Value of f given as a constant, but varied 10%.

(24) 1909 Gebhardt — Steam — No — Formulas for the Flow of Steam in Pipes, Steam Power Plant Eng., p. 568.

A comparison is given of accepted formulas, which were reduced to a standard form to show the variations in constants. The equations for pressure drop appear in three forms, only the first of which considers the friction factor as a variable. These equations and constants are as follows:

a) $\Delta P = \dfrac{C_1 W^2 L (1 + 3.6/d)}{\rho d^5}$.

b) $\Delta P = \dfrac{C_2 W^2 L}{\rho d^5}$.

c) $P_1^{1.96} - P_2^{1.96} = \dfrac{C_3 W^2 L}{d^5}$.

Values of constants.

$C_1 = 0.0001306$ Unwin
$C_1 = 0.0001321$ Babcock
$C_1 = 0.0001306$ Carpenter

$C_2 = 0.0003557$ Gutermuth
$C_2 = 0.0003960$ Geipel & Kilgour
$C_2 = 0.0003370$ Hawksley
$C_2 = 0.0003126$ Hurst
$C_2 = 0.0003133$ Martin

$C_3 = 0.1669$ Ledoux

where P = pressure in psia
W = weight rate of steam flow, lb per min.
L = length of pipe, ft
d = diameter of pipe, in.
ρ = mean density, lb per cu ft

(25) 1912 C. E. Lucke — Steam — No — Engineering Thermodynamics, p. 1116.

Presents formulas of Babcock and Martin for steam flow and states no better formula is available, but warns that engineers working with some fluid over a definite range of conditions should determine for themselves the correct numerical constant to be used in the general equation to meet the given conditions.

(26) 1912 H. Blasius — Water — No — Z. V. D. I., v. 56, pp. 639-43.

Data of Saph and Schoder, as well as Nusselt, were recalculated to show that f is a function of Reynolds number, N_R. Author states that $f = C N_R^{-1}$ in the laminar range of flow, where C is constant.

(27) 1912 H. V. Carpenter — Steam — No — The Flow of Steam Through Pipes, Power, v. 36, p. 889.

Charts based on Babcock equation covering pressures from 1 to 500 psia, and pipes from 1 to 20 inches in diameter.

(28) 1913 H. V. Carpenter — Steam — No — The Flow of Steam Through Pipes, Power, v. 37, p. 816.

Continuation of charts for steam flow based on Babcock equation, and covering pressures from 0.4 inch Hg to 25 psia, and pipe sizes from 2 inches to 60 inches in diameter.

(29) 1914 Stanton and Pannel — Fluids — Yes — Phil. Trans. of Roy. Soc. of London, v. 224A, pp. 199-224.

Test data with oil, water, and air are obtained and compared to results of previous experimenters. Using theories developed by Reynolds and Rayleigh, authors establish that f is a function of N_R. Experimental results shown with f plotted against N_R.

(30) 1914 Verner — Steam — No — ASHVE Trans. v. 20, p. 151.

Value of f given as a constant.

(31) 1915 C. H. Lander — Steam Water — Yes — Surface Friction: Experiments with Steam and Water in Pipes. Proc. Roy. Soc. of London, Ser. A, v. 92, p. 337.

No.	Date	Author	Fluid Used	Experimental Work	Reference Source

The relation between specific volume of dry steam and absolute pressure was considered as $P v^{1.064} = \text{Constant}$. The friction factor was plotted as a function of N_R. Data from Ledoux, Stanton and Pannel, and Reynolds were also plotted on same diagram as further evidence of validity of theory of dynamic similarity.

(32) 1915 Johnston — Steam — No — Eng. Mag. v. 48, p. 694.

Charts presented based on Babcock equation.

(33) 1917 Thies — Steam — No — Power, v. 46, p. 824.

Charts for steam flow in pipes 2½ inches to 16 inches in diameter at pressures of 50 to 250 psig. Method of calculation not given.

(34) 1920 H. M. Brayton — Steam — No — Charts for Graphical Determination of Pipe Sizes and Velocity of Flow of Steam, Power, v. 51, pp. 762-763.

Charts shown for rate of flow of steam in terms of pipe diameter and velocity of steam.

(35) 1920 M. C. Stuart & M. H. Russell — Steam — No — Flow of Steam Through Pipes and Fittings, Jour. Amer. Soc. Nav. Eng., v. 32, p. 473.

Suggests design of steam lines for a desired pressure drop from flow rate and pressure existing. Formula shown based on Babcock equation.

(36) 1921 E. A. May — Steam — No — Proposed Rule for Pipe Sizes, ASHVE Trans., v. 27, p. 26.

Sizes based on Babcock equation.

(37) 1921 E. Owen — Steam — No — Chart for Determining Flow of Steam in Pipes, Pow. Pl. Eng., v. 25, pp. 269-270.

Babcock chart.

(38) 1921 V. F. Davis — Steam — No — Convenient Tables for Steam Flow in Pipes, Power, v. 54, pp. 144-145.

Table gives steam flow in pounds per minute for 100-ft lengths and 1-lb drop; factors given for other lengths and drops. Based on Babcock.

(39) 1921 Konig — Steam — Yes — Elek. und Masch., v. 39, p. 539.

Values given of $f = 0.020$ for wrought-iron and $f = 0.040$ for cast-iron pipes.

(40) 1921 Cotton — Steam — No — Power, v. 53, p. 832.

Charts given for steam flows of 100 to 300,000 lb per hr at pressures of 5 psig to 300 psig. A constant f is used.

(41) 1923 G. B. Massey — Steam — No — Charts for Solving Steam Flow Problems, Heat. and Vent., v. 29, pp. 34-36.

Determination of pressure drop and velocity by Babcock equation.

(42) 1923 W. Mason — Steam — No — Flow of Steam in Pipes, Chem. Trade Jour. and Chem. Eng., v. 72, p. 666.

Simplification of Unwin formula and table showing application.

(43) 1926 Evans — Steam — No — Power, v. 69, p. 947.

Nomogram given using Fritzsche equation.

(44) 1926 McAdams & Sherwood — Fluids — No — Mech. Eng., v. 48, p. 1025.

Discussion of results of Stanton and Pannel that gave f as a function of N_R for air and water. Presents data of Fritzsche, Hussey and Wal-

No.	Date	Author	Fluid Used	Experimental Work	Reference Source

ters, Stockalper (air); Eberle, Carpenter, and Sickles (steam); and Lander (steam and water), on a plot of f versus $\frac{vds}{z}$, where v is velocity in feet per second, d is diameter in inches, s is specific gravity, and z is viscosity in centipoises. Found that the function varied for different pipe materials. States that application of Babcock equation for steam flow is unreliable except under special conditions.

(45) 1927 Rey — Steam — Yes — Bul. Assoc. Tech. Mar. et Aero., v. 31, p. 61.

Lists friction factors from results of:

D'Aubuisson	$f = 0.029$
Ledoux	$f = 0.0216$
Stodla	$f = 0.021$
Odell	$f = 0.0196$
Stockalper	$f = 0.017$
Auscher	$f = 0.016$
Eberle	$f = 0.021$

Rey's experiments included wet and superheated steam, and f values were calculated for those conditions.

(46) 1928 Conrad — Steam — Yes — Power, v. 67, p. 141.

Value of f calculated from test with 8-inch pipe having an equivalent length of 4,839 ft.

(47) 1929 Gallo — Steam — No — Power, v. 69, p. 315.

Chart based on Unwin's equation.

(48) 1930 W. R. Woolrich & L. Holdredge — Steam — No — Low Pressure Steam Characteristics and Steam Flow, v. 2, pp. 400-402.

Tables are based on a drop of pressure of 1 lb in each 1,000 ft of pipe. Correction factors given for drops less than 1 lb and lengths less than 1,000 ft.

(49) 1930 A. B. Eason — Fluids — No — Flow and Measurement of Air and Gases, 2d ed. pp. 38-39.

Digest of references concerning f values with steam flow.

(50) 1931 Editor — Steam — No — Calculating Steam Pipe Sizes and Pressure Losses, Pow. Plt. Eng., v. 35, p. 8.

Babcock formula and Fritzsche formula given. The Fritzsche friction coefficient varies with the 2/7 power of the diameter, and inversely as the 1/7 power of the velocity. Charts are given for solutions by the two equations.

(51) 1932 Harding — Steam — No — Steam Power Plant Engineering.

Author states Unwin or Babcock formula is based on experiments of Riedler and Stockalper (air) and that it is accurate for saturated and slightly superheated steam for pressures below 200 psi.

(52) 1932 W. Frossel — Air — Yes — Flow in Smooth Straight Pipes at Velocities Above and Below Sound Velocity, NACA-TM 844.

Discussion of air flow, and test results plotted with $1/\sqrt{f}$ versus $N_R\sqrt{f}$.

(53) 1932 J. Hulman — Steam — No — Chart for Pressure Drop in Low-Pressure Steam Piping, Heat. Pip., and A.C., v. 4, pp. 343-345.

Chart based on Babcock formula for determining flow rate of steam.

(54) 1933 E. Kemler — Fluids — No — A Study of the Data on the Flow of Fluids in Pipes, ASME Trans., v. 55.

Lists f values reported by 14 different experimenters in steam flow. Values vary from 0.016 to 0.040.

No.	Date	Author	Fluid Used	Experimental Work	Reference Source

(55) 1935 M. W. Benjamin — Fluids — No — How to Use Reynolds Numbers in Piping Calculations, Htg., Pip. and A. C., pp. 519-523.

Author calls those expressions which include a combination of English and Metric units as Reynolds "functions" and not Reynolds Numbers. Conversion factors are presented.

(56) 1937 H. L. Alt — Steam — No — Flow of Steam in Pipes, Dom. Eng., v. 150, pp. 99-101 Oct., and pp. 90-92, Nov.

Tables of steam flow for 100-ft lengths and 1-lb drop. Curves shown for higher pressures.

(57) 1939 J. H. Keenan — Steam Water — Yes — Friction Coefficients for the Compressible Flow of Steam, Jour. of App. Mech., Mar., pp. A11-A20.

Tests with water and steam flowing through a 1-inch steel pipe were conducted with lagged and unlagged pipe. The continuity of data for the two sets of experiments offered evidence that f was substantially the same function of N_R for incompressible and compressible flow up to acoustic velocity. The assumption that no moisture forms in a pipe if the steam is initially slightly superheated is a satisfactory approximation which seemed to fit the observed phenomena better than the assumption of a stable two-phase state. The f was plotted as a function of N_R.

(58) 1942 Lobo, Friend, and Skaperdas — Fluids — No — Ind. Eng. Chem., v. 34, p. 821.

Pressure drop in the flow of compressible fluids is affected by changes in kinetic energy and fluid density. These effects can be determined from a formula and a chart. However, both f and n must be known, n being the exponent in the equation: $Pv^n = C$.

(59) 1943 H. Rouse — Fluids — No — Evolution of Boundary Roughness, Proc. Second Hyd. Conf., U. of Iowa Bul. 27, p. 105.

Discusses theories and work of many experimenters, with special reference to those of Karman. Author plots f versus N_R diagram from results of eight investigators with water, and finds good correlation with theory. A graph is also presented using as coordinates the parameters $1/\sqrt{f}$ and $N_R\sqrt{f}$ of Karman's analysis. Constant r/e value lines for relative roughness are shown in turbulent range, where r is radius in inches and e is absolute roughness in inches.

(60) 1943 E. N. Kemler — Fluids — No — How to Size Piping for Steam, Gases, and Vapors, Heat. and Vent., v. 40, pp. 52-69.

Chart method is given for pipe sizing, based on compressible flow formula. Charts are given for specific gravity, kinematic viscosity, and conversions to other viscosities.

(61) 1943 Editor — Steam — No — Steam Pipe Sizing Chart, Heat. and Vent., v. 40, p. 76a-b.

Based on Unwin formula.

(62) 1944 L. F. Moody — Fluids — No — Friction Factors for Pipe Flow, ASME Trans. v. 66, p. 671.

Gives chart of friction factor versus N_R. Chart is based on theories and experimental results of many investigators.

(63) 1945 Editor — Steam — No — Sizing Steam Mains, Heat. and Vent., v. 42, p. 82, July; p. 74, Aug.

Based on Babcock formula for 2 psig.

PART B.

CORRELATION OF STEAM FLOW DATA WITH MOODY CHART

From the discussion in Part A it can be concluded that the best approach to the study of steam flow in pipes consists in utilizing the recent concepts of fluid flow, and in particular the convenient chart prepared by Moody. This chart, shown in Fig. 1, gives the relation between friction factor and Reynolds number for various degrees of roughness of the surface of the pipe. For most practical applications the right hand section of the chart, designated as the "transition zone" and "complete turbulence" is of importance. The bottom curve, designated for "smooth pipes" is seldom encountered in practical applications. The remaining curves are for varying degrees of roughness, in which e represents the average height of the roughness or projections in the interior of the pipe, as shown in Table 2, and D represents the internal diameter of the pipe.

(1) Hence, for the same type of pipe, such as commercial steel, for which the e value has been given by Moody to be about 0.00015 ft, the value of e/D will decrease as the pipe diameter is increased.

(2) Furthermore, for a given pipe diameter for which the e/D value is fixed, the friction factor can be seen to increase as the Reynolds number is decreased.

The Moody chart has been found to be applicable to the flow of water, air, and other fluids.

a. Correlation of Experimental Data on Steam Flow

The next step in the present analysis consisted, therefore, in determining whether the original steam flow data of several investigators could be correlated with the Moody chart. Such a correlation is shown in Fig. 2, in which data from Carpenter and Sickles (17), Eberle (23), and Lander (31) were plotted. The reasons for the conclusions reached by the original investigators becomes apparent from a study of the plotted data.

(1) For example, the data of Carpenter and Sickles covered a small range of Reynolds number (from 4×10^5 to 6.2×10^5) in a mildly turbulent zone. The conclusion reached by the investigators that the friction factor varied only with the diameter would be acceptable in this narrow range.

(2) On the other hand, the data of Eberle were practically in the range of complete turbulence (Reynolds number from 1×10^6 to 4.2×10^6), in which the viscosity does not influence the friction factor. That is, the pressure drop is not a function of Reynolds number. Therefore, the conclusion reached by Eberle that the friction factor was constant would be true in the range of Reynolds number in which his work was conducted.

(3) Lander's data covered a larger range of Reynolds number (from 2×10^4 to 5.2×10^5) and formed the basis of the contention by Lander that the friction factor was a function of Reynolds number.

The conclusions drawn by Eberle and by Carpenter and Sickles were correct for the limited conditions under which their studies were made. In some respects this review of historical events is reminiscent of the fable of the blind men describing an elephant. The fact is most significant that the apparent discrepancies between the conclusions presented in the original papers can be rationalized. Of even greater importance is the fact that the data of Carpenter and Sickles, which were originally used to justify the Unwin-Babcock relationship, can be seen to correlate much better when analyzed by the Reynolds number concept.

TABLE 2.—VALUES OF ABSOLUTE SURFACE ROUGHNESS FOR DIFFERENT KINDS OF PIPE.

Type of Pipe	Value of e	
	Inches	Feet
Smooth-drawn tubing, brass, lead, glass, centrifugally-spun cement, bituminous lining, transite, etc.	0.000,060	0.000,005
Commercial steel, or Wrought iron	0.001,80	0.000,15
Asphalted cast iron	0.004,8	0.000,4
Galvanized iron	0.006	0.000,5
Cast iron	0.010,2	0.000,85
Wood stave	0.0072 to 0.036	0.0006 to 0.003
Concrete	0.012 to 0.12 Average 0.036	Ave. 0.003
Riveted steel	0.036 to 0.36 Average 0.12	Ave. 0.010

(From "An Approximate Formula for Pipe Friction Factors," L. F. Moody, Mech. Eng., v. 69, p. 1005, 1947).

b. Discrepancies Between Old and New Data

It is of some interest to note the discrepancies that arise between the values obtained from the Moody chart and those from the application of the Unwin-Babcock equation, in which the friction factor was assumed to be a function of diameter alone. If the following equation is considered to represent the Darcy-Weisbach friction factor, as claimed by Unwin and Babcock:

$$f/4 = k\ (1 + 3.6/d),$$
$$\text{and } k = 0.0027,$$

then for each and every value of the diameter d there exists a corresponding value of f. For example, for d

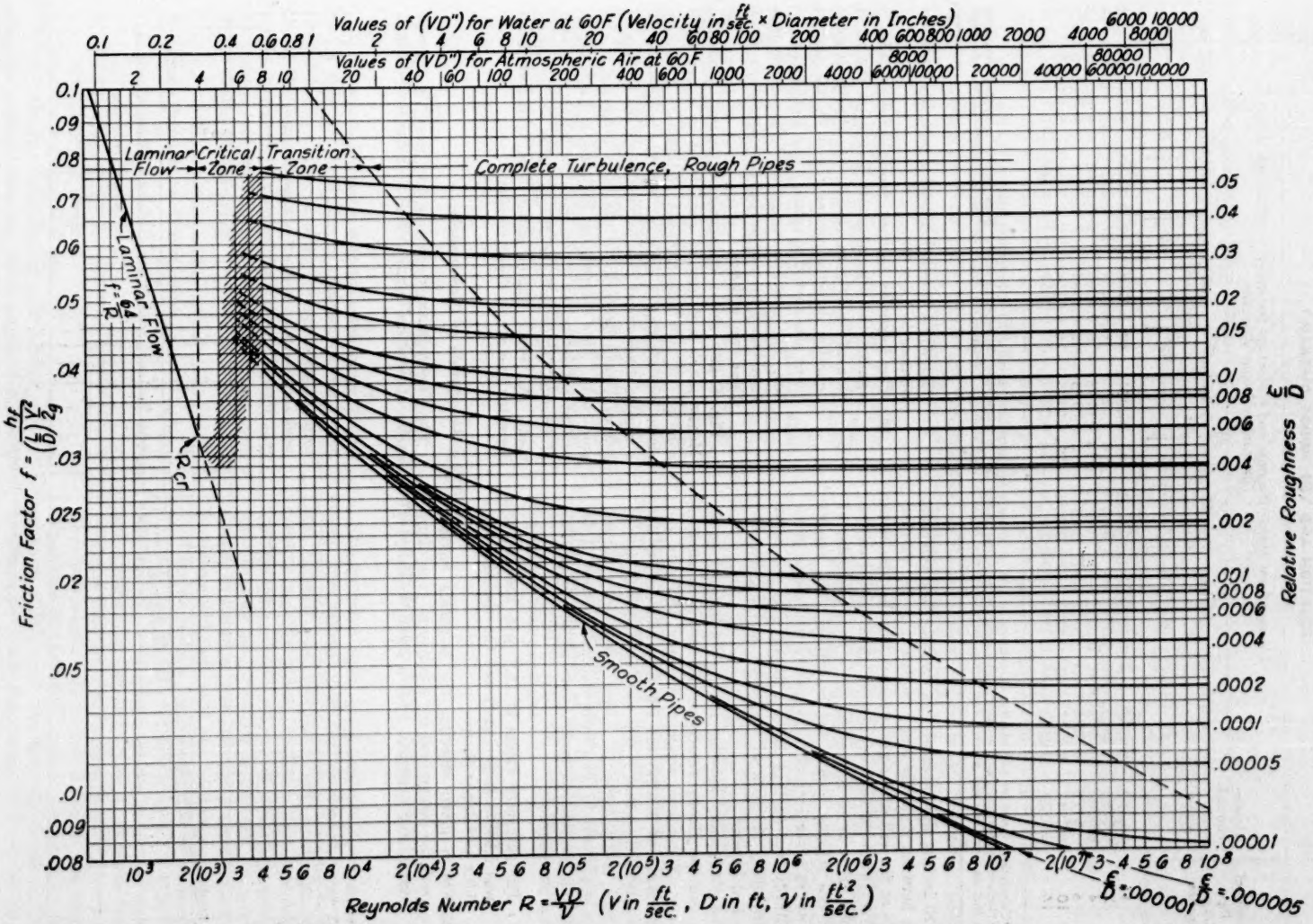

Values of (VD") for Water at 60F (Velocity in ft/sec × Diameter in Inches)
Values of (VD") for Atmospheric Air at 60F
Laminar Flow
Critical Zone
Transition Zone
Complete Turbulence, Rough Pipes
Laminar Flow f = 64/R
R cr
Smooth Pipes
Friction Factor f = (hf/(L/D))(V²/2g)
Relative Roughness ε/D
Reynolds Number R = VD/ν (V in ft/sec, D in ft, ν in ft²/sec)
ε/D = .000001
ε/D = .000005

Fig. 1. Moody chart showing friction factors for fluid flow in circular pipes. Reprinted by permission from ASME Transactions, November, 1944.

TABLE 3.—COMPARISON OF DARCY-WEISBACH FRICTION FACTOR AS OBTAINED FROM THE UNWIN-BABCOCK EQUATION AND THE MOODY DIAGRAM.*

Nominal Pipe Diam., Inches	Unwin-Babcock f Value	f Values from Moody Diagram and Percentage Deviation** of Babcock Values at Various Steam Velocities													
		5 fps		15 fps		25 fps		40 fps		60 fps		100 fps		200 fps	
		f	%	f	%	f	%	f	%	f	%	f	%	f	%
1	0.0480	0.0520	— 8	0.0370	30	0.0330	45	0.0301	59	0.0284	69	0.0268	79	0.0249	93
2	0.0296	0.0400	—26	0.0310	— 5	0.0275	8	0.0251	18	0.0239	24	0.0221	34	0.0209	42
4	0.0204	0.0340	—40	0.0260	—21	0.0235	—13	0.0218	— 6	0.0205	0	0.0193	6	0.0180	13
6	0.0172	0.0300	—43	0.0235	—27	0.0211	—18	0.0195	—12	0.0184	— 7	0.0171	1	0.0160	7
10	0.0147	0.0261	—44	0.0208	—29	0.0190	—23	0.0175	—16	0.0164	—10	0.0154	— 5	0.0145	1
16	0.0134	0.0240	—44	0.0191	—30	0.0176	—24	0.0161	—17	0.0153	—12	0.0143	— 6	0.0136	— 1

*Calculations based on schedule No. 40 commercial steel or wrought iron pipe (e = 0.00015 ft) and saturated steam at 15.7 psia.
**Percentage deviation with a positive sign indicates a friction factor that is larger than the required value. Thus positive percentage deviations show that an oversizing will result if the Unwin-Babcock friction factor is used in design. Negative percentage deviations describe the opposite trend.

= 10 inches, the value of f is 0.0147. This relationship between diameter and f is shown by the vertical scale at the left and right sides of Fig. 3. The slope of the Unwin-Babcock expression when plotted on the Moody chart is zero; that is, for a fixed diameter of pipe the friction curves are horizontal. The results are not in agreement with the generalized slopes given by Moody, nor do they agree with slope of the curve representing the data of Carpenter and Sickles, Eberle, and Lander.

The discrepancy between the Unwin-Babcock equation and the Moody values can be shown in another manner. For a fixed steam pressure of 15.7 psia and temperature of 215.3F, the viscosity and density are each constant, so that it was possible to show lines of constant steam velocity. These iso-velocity curves, which apply only to the Unwin-Babcock method of determining the friction factor, were plotted by the following procedure:

(1) For saturated steam at 15.7 psia, the density was 0.03973 lb per cu ft and the viscosity was 9.0×10^{-6} lb per ft sec.

(2) For a given velocity, the Reynolds number could be determined for a range of pipe diameters. For example, with a steam velocity of 25 fps in a two-inch diameter pipe, the Reynolds number is 1.9×10^4.

(3) The Reynolds number was plotted on Fig. 3 against the pipe diameter shown on the right side of the figure. Since the Unwin-Babcock equation directly relates f and D, the plotted point also served to relate f and Reynolds number. The complete curve for 25 fps velocity was established by considering pipe diameters other than two inches.

Fig. 3 also shows superimposed curves from the Moody chart, and may be considered as a graphical solution of two simultaneous equations. A Moody curve representing a constant relative roughness for a specific diameter of pipe will intercept the horizontal line of Unwin-Babcock for the same diameter at one point only. This intersection indicates a diameter, as well as a velocity, at which the Unwin-Babcock value of friction factor and the Moody value are in agreement. All other values along that Unwin-Babcock diameter line are in disagreement.

c. Magnitude of Discrepancies

The Unwin-Babcock equation does result in discrepancies of practical significance. For example, with a

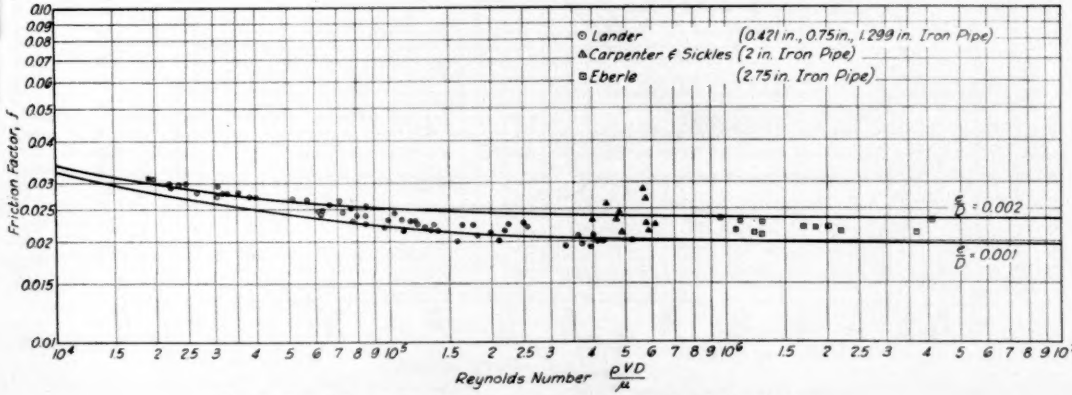

Lander (0.421 in., 0.75 in., 1.299 in. Iron Pipe)
Carpenter & Sickles (2 in. Iron Pipe)
Eberle (2.75 in. Iron Pipe)
Friction Factor, f
Reynolds Number DVD/μ
ε/D = 0.002
ε/D = 0.001

Fig. 2. Correlation of Experimental steam flow data with the Moody chart.

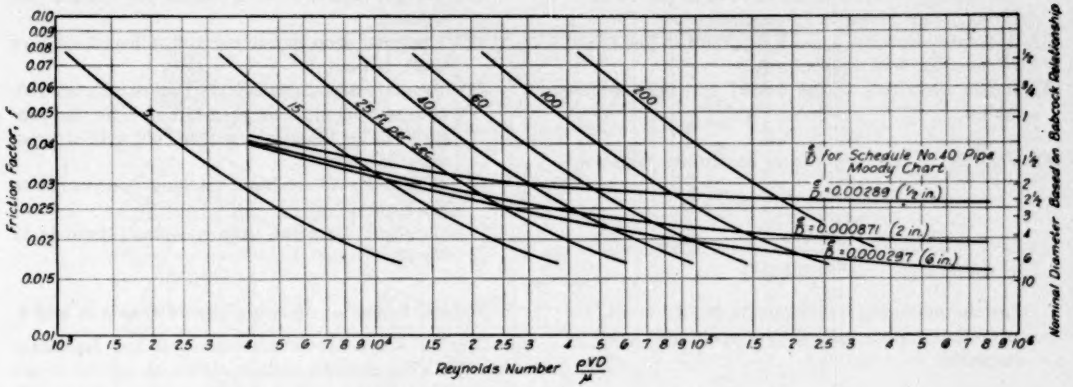


Fig. 3. Comparison of friction factors obtained with Unwin-Babcock equation with those from the Moody relationships (showing diameters and velocities at which the relationships are in agreement).

four-inch diameter pipe and a steam flow velocity of 60 fps the results are in substantial agreement with those from the Moody chart. However, with the same velocity of 60 fps and a one-inch diameter pipe, the Unwin-Babcock values are about 70% greater than those from the Moody chart. For the purpose of showing the discrepancies and the relative magnitudes of the deviations in results by the two methods, a few values are presented in Table 3.

From the evidence presented, it appears that the extrapolation of the Unwin-Babcock equation to any and all pressure and temperature conditions is not warranted. In some cases, the use of the equation may result in pipe sizes that are too small, and in other cases may result in oversized pipes. In this connection, the following quotation from Power Plant Engineering (v. 35, p. 8, Jan. 1931) is of interest:

> "Early experience at Hell Gate (steam power station) with moderate pressure, superheated steam showed that the actual pressure losses were only about half of those calculated with the Babcock coefficient. Recent experiences at Lakeside with small diameter superheated tubes confirm this, as the actual drop is only 18 instead of 35 pounds as calculated from the Babcock formula."

The only logical conclusion that can be reached from the evidence presented in this section is that the original data of Carpenter and Sickles, Eberle, and Lander are in good agreement, as judged by the Reynolds number concept, and that the fault lies not in the data, but in the analysis made by others before fluid flow theory had been developed.

PART C.

THE PAGE-KONZO CHARTS FOR SIZING OF PIPES FOR STEAM FLOW

By the use of similarity concepts incorporated in the Moody chart for fluid flow, a new method can be derived for the sizing of steam pipes. Two working charts that summarize the method in graphical form will be presented. A detailed example of the necessary calculations that were made to establish a single point on the charts will be given.

a. Sample Problem by Computation

If the following variables are known:

(1) Absolute viscosity, μ
(2) Density, ρ
(3) Velocity of steam, V
(4) Inside diameter of pipe, D
(5) Absolute roughness of pipe surface, e

then the pressure drop per 100-ft length of pipe may be calculated by the Moody chart and equation (1).

The variables listed are functions of other parameters. For example, the first two variables of absolute viscosity and density depend upon the steam pressure and the steam condition (i.e., wet, dry, or superheated). The fourth variable of inside diameter depends upon the nominal pipe size and the schedule number of the pipe. For example, a two-inch schedule 40 commercial-steel pipe has an inside diameter of 2.067 inches, while a two-inch schedule 80 commercial-steel pipe has an inside diameter of 1.939 inch. The fifth variable of absolute surface roughness depends upon the material used in the pipe, as shown in Table 2.

Assume that the pressure drop is desired in 37 ft of three-inch schedule 40 commercial-steel pipe when 12 lb per min. of saturated steam is flowing at an initial pressure of 15.7 psia. The first step of the solution is to determine steam properties. This can be done in the ten steps which follow:

(1) Density, ρ, $= 1/25.17 = 0.03973$ lb per cu ft (from steam tables by interpolation).

(2) Absolute viscosity, μ, $= 9.0 \times 10^{-6}$ lb per ft sec. (From Fig. 4 in Appendix A.)

(3) Inside diameter, D, $= 0.2557$ ft (from piping tables).

(4) Velocity, $V = \frac{W}{\rho A}$, (from continuity equation)

$$= \frac{12}{0.03973\ [\pi/4 \times (0.2557)^2]} = 5{,}882 \text{ fpm.}$$

For the next step involving the Moody chart, the Reynolds number and relative roughness must be computed.

(5) $N_R = \frac{\rho V D}{\mu} =$

$$\frac{0.03973 \times 5{,}882 \times 0.2557}{9.0 \times 10^{-6} \times 60} = 1.107 \times 10^5.$$

(6) Absolute surface roughness, $e = 0.00015$ ft (from Table 2).

(7) Relative roughness, $e/D = \frac{0.00015}{0.2557} = 0.000{,}5867.$

On the Moody chart, the intersection of the e/D line of 0.000,5867 and the N_R line of 1.107×10^5 is located.

(8) Friction factor, $f = 0.0206$ (from Moody chart, Fig. 1).

Appropriate values are substituted in equation (1) to obtain:

(9) Head loss, $\triangle h = \frac{f L v^2}{D\ 2g}$

$$= \frac{0.0206 \times 37 \times (5882)^2}{0.2557 \times 2 \times 32.2 \times 3600} = 446 \text{ ft.}$$

(10) Pressure drop, $\triangle P = \frac{\rho \triangle h}{144}$

$$= \frac{0.03973 \times 446}{144} = 0.123 \text{ psi.}$$

b. Presentation of Working Charts

Tedious calculations of the preceding type can be practically eliminated by the use of working charts shown as Charts A and B. The computations were made for schedule 40 commercial-steel pipe only. Chart A was derived for saturated steam at pressures ranging from 0.0 psig to 1.9 psig (14.7 psia to 16.6 psia), while Chart B was for pressures ranging from 2.0 psig to 5.0 psig (16.7 psia to 19.7 psia). The chart scales show the following variables:

(1) Weight rate of flow in pounds per minute (abscissa).

(2) Pressure drop in psi per 100-ft length of pipe (left ordinate).

(3) Pressure drop in ounces per square inch per 100-ft length of pipe, (right ordinate) for the convenience of those who utilize this unit of pressure drop.

(4) Constant velocity lines (sloping downwards to the right).

(5) Constant diameter lines (sloping upwards to the right).

c. Typical Examples Showing Use of Charts A and B

Case 1. When the pressure drop is the dependent variable. The sample problem shown in section *b* can be readily solved by means of the working charts. It was required to determine the pressure drop in 37 ft of three-inch schedule 40 commercial-steel pipe when 12 pounds per minute of saturated steam was flowing at an initial pressure of 15.7 psia. Chart A will be used since it applies to schedule 40 pipe and to a pressure range of 14.7 to 16.6 psia.

Locate the flow rate of 12 pounds per minute on the abscissa. Proceed vertically on the chart until the three-inch diameter line is intersected. Proceed horizontally to the left ordinate to obtain a pressure drop of 0.0333 psi per 100 ft of length. The pressure drop for 37 ft of pipe is 0.37×0.0333, or 0.123 psi. This result is the same as that of the detailed method shown in the previous section.

Case 2. When the weight flow rate is the dependent variable. What is the flow rate in pounds per minute of saturated steam at 18.0 psia through a schedule 40 commercial-steel pipe of one-inch diameter and 190 ft long, for a pressure drop of 1.1 psi?

The pressure drop per 100 ft length is $1.1 \times \frac{100}{190}$, or 0.579 psi. Since the initial pressure is 18 psia, utilize Chart B. Locate the value of 0.579 psi on the left ordinate, and proceed horizontally until the intersection with the one-inch diameter line is reached. Proceed vertically to the abscissa to obtain a weight flow rate of 0.98 pound per minute.

Case 3. When the pipe diameter is the dependent variable. When given an initial pressure of 19 psia, a pressure drop of 0.5 psi per 100-ft length, and saturated steam to be transported at a rate of 25 pounds per minute, what are the pipe size and steam velocity?

Select Chart B for pressures between 16.7 to 19.7 psia. Locate 0.5 psi on the left ordinate and proceed horizontally. Next locate 25 lb per min on the ordinate and proceed vertically. The intersection of these two lines lies between two commercial pipe sizes. A four-inch pipe could be used, but the weight flow is 32.9 lb per min, which is considerably larger than necessary. On the other hand, a 3½-inch pipe gives a weight flow of 23.1 pounds per minute. The 3½-inch pipe would be preferred, since a flow rate of 25 pounds per minute would result in a pressure drop of 0.575 psi, which is only slightly larger than the desired value of 0.5 psi. The steam velocity is 8,000 fpm.

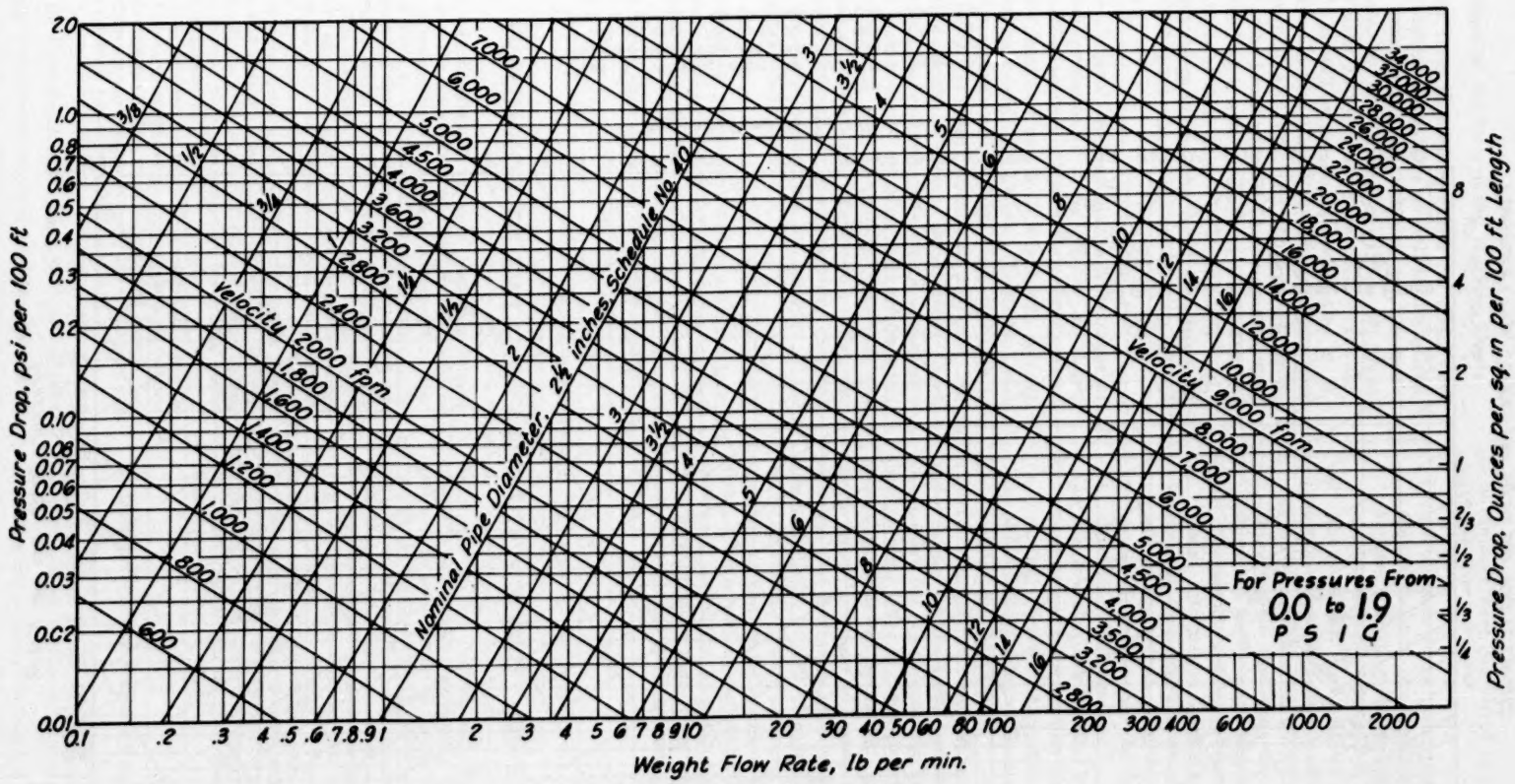

Pressure Drop, psi per 100 ft
Pressure Drop, Ounces per sq. in per 100 ft Length
Weight Flow Rate, lb per min.
Nominal Pipe Diameter, 2½ inches, Schedule No. 40
Velocity, 2000 fpm
Velocity, 9000 fpm
For Pressures From 0.0 to 1.9 P S I G

Chart A. Working chart for steam flow based on saturated steam, covering pressures from 0.0 psi gage to 1.9 psi gage (14.7 psia to 16.6 psia). Chart applies to schedule 40 commercial wrought-steel pipe.

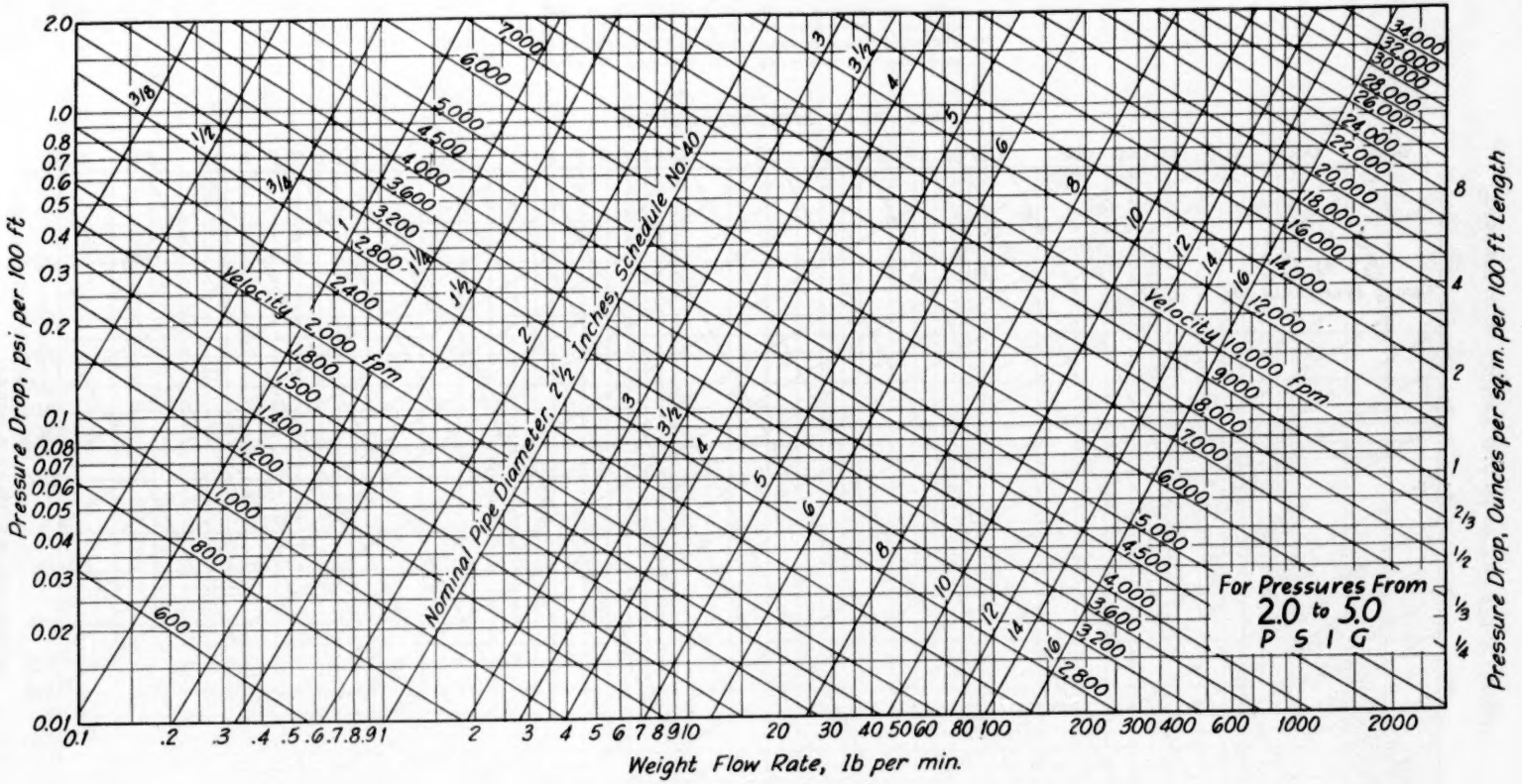

Pressure Drop, psi per 100 ft
Weight Flow Rate, lb per min.
Pressure Drop, Ounces per sq. in. per 100 ft Length
Nominal Pipe Diameter, 2½ Inches, Schedule No. 40
Velocity 2,000 fpm
Velocity 10,000 fpm
For Pressures From 2.0 to 5.0 P S I G

Chart B. Working chart for steam flow based on saturated steam, covering pressures from 2.0 psi gage to 5.0 psi gage (16.7 psia to 19.7 psia). Chart applies to schedule 40 commercial wrought-steel pipe.

d. Advantages of the Form of the Working Charts

Any given form of working charts for steam flow will have inherent advantages as well as limitations. A careful examination was made of the alignment charts issued by the Crane Co. (Flow of Fluids Through Valves, Fittings, and Pipe, Tech. Paper 409, May 1942), as well as the charts prepared by E. N. Kemler (How to Size Piping for Steam, Gases, and Vapors, HEATING AND VENTILATING, v. 40, pp. 52-69, Oct. 1943). The forms shown in Charts A and B were finally decided upon after a study of the limitations and advantages of these as well as other forms.

The forms shown in Charts A and B have two limitations, which have not been considered as unsurmountable.

(1) For complete coverage over a wide range of steam pressures, a large number of charts would be required. Chart A for a range of pressures from 14.7 psia to 16.6 psia was actually based on values for 15.7 psia. Similarly, Chart B for a range of pressures from 16.7 psia to 19.7 psia was based on values for 18.0 psia. For higher steam pressures, successively larger ranges of steam pressures could be used to give the same order of accuracy as those embodied in Charts A and B. In this connection, the maximum deviation in all the values shown was limited to seven per cent, which was regarded as reasonable considering the accuracy of the original data involved.

(2) In order to cover the cases of pipes other than schedule 40, commercial steel or wrought iron, either separate charts or conversion factors would be necessary.

In spite of the obvious limitations of the form used, the advantages were considered to outweigh the disadvantages:

(1) All the data for a particular steam condition are presented on one chart. For most practical applications, the engineer is able to solve a problem without reference to other charts.

(2) The solution to any problem can be started at any place on the chart, providing any two of the four variables are known. As shown by the three sample problems, any variable on the chart can be the dependent variable.

(3) The complete determination of the problem is made. Information is obtained not only about pressure drop, but also weight flow, diameter, and velocity. It is possible to observe how a change in any one of the four variables will affect the other three.

(4) The flow charts are similar in form to those in common use for water flow and air flow, so that familiarity with the existing charts shown in the ASHVE Guide can be extended to these new charts for steam flow.

Charts A and B for low-pressure steam flow are intended mainly for the heating engineer. If a demand should exist for charts covering higher steam pressures or other types of pipes, such charts can be prepared. As indicated previously, a given chart for higher steam pressures will cover a larger range of pressures than the ranges included in Charts A and B. Hence, the total number of charts required to cover the entire range of steam pressures from 14.7 psia to, say, 300 psia will not be as numerous as might be surmised. The non-linear variations of certain parameters, such as density, permit a given chart prepared for a high pressure range to cover a wider range of pressures with the same accuracy as those used for Charts A and B.

APPENDIX A.

EVALUATION OF DATA ON ABSOLUTE VISCOSITY OF STEAM

For the determination of Reynolds number a reliable source of data for the absolute viscosity of steam must be available. A comprehensive survey of literature was made as listed in Table 4. The values of viscosity showed deviations between the various sources so that a selection was made of values which were considered to be most representative. The divergences in the data from the various sources are understandable, since the determination of steam viscosity presents formidable problems in experimentation. The control of constant pressures and temperatures through a finite distance involves complex instrumentation and design of equipment, as well as involved techniques. It is little wonder, therefore, that viscosity values for extreme high pressures near the critical region show lack of agreement.

In general, the various original investigations can be classified into three groups of pressure regions, as follows:

(1) high-pressure region, from 500 psia and higher,
(2) medium-pressure region, between 100 to 500 psia, and
(3) low-pressure region, up to 100 psia.

a. Data for High Pressure Region

According to the kinetic theory of gases the absolute viscosity of a gas is a function of temperature alone. This theory is based on the assumption that the size of the molecules is small compared to the mean free path, and seems to be substantiated by experimental evidence in the low pressure region. For high pressures, however, evidence exists that the absolute viscosity of a gas is a function of both temperature and pressure. In the case of steam, the evidence is somewhat confusing. For example, Schougayew (4)* and Sigwart (5) found that pressure had little effect on the viscosity of steam in the high pressure region. On the other hand, Hawkins, Solberg, and Potter (3, 7) found the opposite to be true. Timroth (6) obtained a pressure effect less than that obtained by Hawkins and his associates. No general agreement has been reached as to the most reliable data.

b. Data for Medium Pressure Region

In the medium pressure region of 100 to 500 psia, the variations in the experimental values of absolute viscosity are not too large, and are of the order of five to 20%.

*Numbers refer to references in Table 4.

TABLE 4.—REFERENCES ON STEAM VISCOSITY DATA.

References No. (1) Through No. (7) Refer to Original Determinations.

No.	Author	Reference
(1)	Speyerer	V. D. I. Forsch., Berlin, No. 273, 1925.

Data from 16 to 148 psia obtained with capillary viscometer.

(2)	Schiller	Forsch., Gebiete Ingenieurw., v. 5, p. 71, 1934.

Data from 74 to 440 psia obtained with calibrated discharge nozzle.

(3)	Hawkins, Solberg, and Potter	ASME Trans., v. 57, p. 395, 1935.

High pressure data up to 3,500 psia obtained with falling body viscometer. Viscosity shown to be a function of pressure as well as temperature. Due to inherent difficulties in the application of the falling body viscometer, these data were superseded with those from 1940 test (reference 7).

(4)	Schougayew	J. Exp. Theor. Phy. (USSR) v. 3, p. 247, 1933, also v. 4, p. 760, 1934. Investiya, V. T. I., No. 7, p. 47, 1934.

Low and high pressure data obtained with capillary viscometer. Viscosity was found to be independent of pressure.

(5)	Sigwart	Forsch., Gebiete Ingenieurw., v. 7, p. 125 and p. 310, 1936.

High pressure data given for water and steam through critical region. A small change in viscosity was found with pressure.

(6)	Timroth and Vargaftik	J. Tech. Phy. (USSR), v. 9, p. 461, 1939; J. Phy. (USSR), v. 2, p. 419, 1940.

High pressure data up to 250 atmospheres.

(7)	Hawkins, Solberg, and Potter	ASME Trans., v. 62, p. 677, 1940.

Experimentally redetermined data of 1935 (reference 3) with a capillary viscometer. Viscosity again found to be a function of pressure and temperature. Proposed following equation to represent viscosity data:

$$\mu' = (13.421 = 0.0141\ t)\left(1 + \frac{0.1753}{v} - \frac{0.0116}{v^2}\right)10^{-3}$$

where μ' = viscosity in centipoises,
t = temperature in F,
v = specific volume in cu ft per lb.

(Following references do not present original investigations)

(8)	Editor	Smithsonian Physical Tables, p. 217, 1932.

Viscosity of water vapor at 32F, 60.8F, and 212F.

(9)	Daugherty	ASME Trans., v. 57, p. 193, 1935.

Limited data presented in chart form. No reference data given.

(10)	Lieb	ASME Trans., v. 62, p. 677, 1940 (discussion in reference 7). Combustion, v. 12, p. 45, Dec. 1940.

Derives equations for computing viscosity at any pressure and temperature. When constants determined from reference 7 are included, the equation is of the form:

$$\mu = (0.754 \times 10^{-8})\frac{\sqrt{T}}{1 + \frac{800}{T}} \cdot \frac{\frac{v}{4b}\left(1 - \frac{b}{v}\right)^2}{\sqrt{\left(\frac{v}{4b} + \frac{3}{4}\right)^2 + \frac{\theta}{T}} - \sqrt{1 + \frac{\theta}{T}}}$$

where μ = viscosity in lb per ft sec,
T = temperature in deg Rankin,
v = specific volume in cu ft per lb,
b = 0.016 cu ft per lb,
θ = 19,000 deg Rankin

Author presents convenient graph of absolute viscosity versus temperature for all pressures up to critical point.

No.	Author	Reference
(11)	Keyes	ASME Trans., v. 62, p. 677, 1940 (discussion in reference 7).

Presents equation for computing viscosity at any pressure and temperature:

$$\mu'' = \frac{1.851 \times 10^{-8}\sqrt{T}}{1 + \frac{680.1}{T}} - (0.0151 - 5.9 \times 10^{-3}\ p)\ p \times 10^{-4}$$

μ'' = viscosity in poises,
p = pressure in standard atmospheres,
T = temperature in deg Kelvin

(12)	Editor	Handbook of Chem. and Phys., 30th ed., p. 1739, 1947.

Viscosity values for water vapor from 212F to 752F. Reference 4 is source for the values.

(13)	Leutwiler	Notes on Design of Steam Power Plants, p. 226, 1943.

Presents equation for computing viscosity at temperatures above 212F. Pressure does not enter into calculations. Source for equation is said to be Walker and Crocker.

$$\mu' = 0.0083 + 0.000{,}021{,}33\ t$$

where μ' = viscosity in centipoises,
t = temperature in F.

(14)	Keenan and Keyes	Thermodynamic Properties of Steam, 21st print, p. 76, 1950.

Limited data from 0 psia to 3,500 psia are presented. These are based on equation given in introduction of book for viscosity when both pressure and temperature are known:

$$\mu'' = \left(\frac{1.501 \times 10^{-8}\sqrt{T}}{1 + \frac{446.8}{T}}\right) + 10^{-4}\left[\frac{(6.36 - 2.31 \times 10^{-3} \times 10^{1500/T})\ P}{T} + (0.0389 \times 10^{-0.005470T})\ p^2\right]$$

Where T = temperature in deg Kelvin
P = pressure in kg per sq cm,
μ'' = viscosity in poises

Sources for the equation are reference numbers 3, 5, 6, 7, and Plank (Forsch., Gebiete Ingenieurw., v. 4, p. 1, 1933).

(15)	Gaffert	Heat., Pip. and Air Cond., p. 174, March 1938.

Chart based on data of references 1, 2, and 3.

(16)	Editors	Int. Crit. Tables, v. 5, p. 4, 1929.

Table for saturated steam from 32F to 500F. Reference source is Smith (Proc. Roy. Soc. of London, Math. and Phys. Sci., v. 106, p. 83, 1924).

(17)	Hutte	Hutte, Des Ingenieurs Taschenuqe.

Viscosities presented in tabular form for steam at standard atmospheric pressure and temperatures from 212F to 932F.

(18)	Comings, Mayland, and Egly	Univ. of Ill., Eng. Exp. Sta. Bul. 354, 1944.

Graphs presented by which the viscosity of high pressure steam can be determined for a given pressure and temperature, if the viscosity is known at atmospheric pressure and temperature.

(19)	Hawkins, Sibbitt, and Solberg	ASME Trans., v. 70, p. 19, 1948

Review of data on viscosity of water vapor. Authors point out results which they believe are questionable because of method or analysis used by the experimenters. Timroth (6) and Hawkins (7) data believed to be most accurate, but these are not in agreement. Timroth values in high pressure range are about 75% of Hawkins values at same pressure.

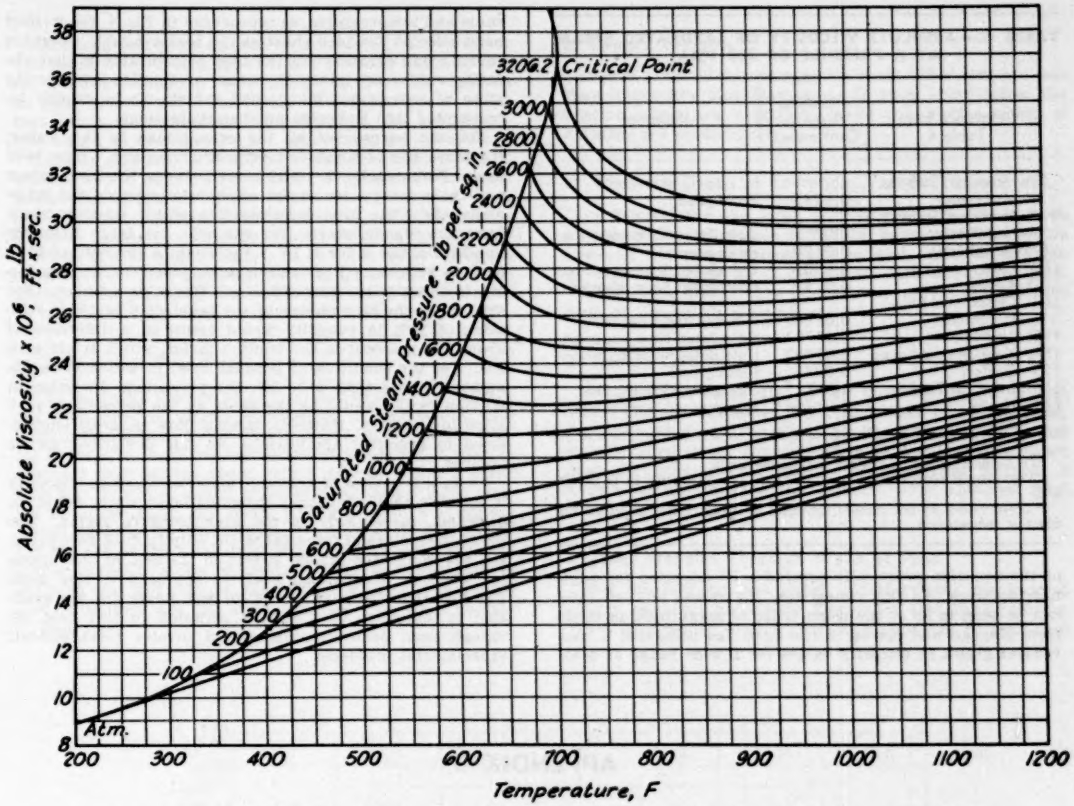


Fig. 4. Lieb chart for absolute viscosity of steam. Reprinted by permission from Combustion, December, 1940.

c. Data for Low Pressure Region

For the low pressure region of 0 to 100 psia, viscosity values for saturated and superheated steam are available, but not for wet steam. The data of Speyerer (1) and those in the International Critical Tables (16) are frequently cited in reference texts. However, these data give slightly lower values than the later work of Hawkins (7).

As may be observed from the abstracts in Table 4, a number of equations have been presented by which viscosity values can be calculated. Unfortunately, no consistent set of viscosity, pressure, or temperature units have been used. Furthermore, some of the equations are extremely complicated so that tedious calculations are necessary for the determination of absolute viscosities.

For the purpose of comparing the various values, all expressed in a consistent set of units, the viscosities listed in Tables 5 and 6 were calculated. Table 5 gives viscosities of saturated steam at atmospheric pressure. In general, the values from references (7) and (9) seem to deviate the most from a mean value. Similar values in Table 6 for saturated steam at 300 psia indicate that references (3) and (15) seem to deviate the most from a mean value.

The values obtained from Keenan and Keys (14) and Lieb (10) are worthy of special mention. The complicated equation given in reference (14) was based on source material from five separate investigations. Since the values shown in Tables 5 and 6 for reference (14) appear to be consistent with the majority of results of the other authors, considerable weight has been given to the proposed equation of Keenan and Keyes. On the other hand, the complexity

TABLE 5.—ABSOLUTE VISCOSITY OF SATURATED STEAM AT STANDARD ATMOSPHERIC PRESSURE.

Reference from Table 4	Absolute Viscosity, Centipoises[1]	Remarks
(3) Hawkins, Solberg, and Potter	0.0122	Extrapolated from authors' data
(7) Hawkins, Solberg, and Potter	0.01652	Calculated from authors' equation
(8) Smithsonian Tables	0.0132	From tabular data
(9) Dougherty	0.0155	From graph
(10) Lieb	0.0134	Calculated from author's equation
(11) Keyes	0.01283	Calculated from author's equation
(12) Chem. and Phys. Handbook	0.01255	From tabular data
(13) Leutwiler	0.01282	Calculated from equation
(14) Keenan and Keyes	0.01313	Calculated from authors' equation
(16) Int. Crit. Tables	0.0127	From tabular data
(17) Hutte	0.01271	From tabular data

[1]To convert values to English engineering units:
(Viscosity in centipoises) × (0.000,672) = (Viscosity in lb per ft sec)

TABLE 6.—ABSOLUTE VISCOSITY OF SATURATED STEAM AT A PRESSURE OF 300 PSIA.

Reference from Table 4	Absolute Viscosity, Centipoises[1]	Remarks
(3) Hawkins, Solberg, and Potter	0.0245	From graph
(7) Hawkins, Solberg, and Potter	0.0215	Calculated from equation
(9) Daugherty	0.0190	From graph
(10) Lieb	0.0201	Calculated from equation
(11) Keyes	0.0199	Calculated from equation
(12) Chem. and Phys. Handbook	0.01687*	Interpolated from table
(13) Leutwiler	0.0172*	Calculated from equation
(14) Keenan and Keyes	0.01987	Calculated from equation
(15) Gaffert	0.0245	From graph
(16) Int. Crit. Tables	0.0171*	Interpolated from table
(17) Hutte	0.01701*	Interpolated from table

[1]To convert values to English engineering units:
(Viscosity in centipoises) × (0.000,672) = (Viscosity in lb per ft sec)

*These values do not include the effect of pressure, but do allow for effect of temperature.

of the equation practically precludes its adoption for engineering work. In this connection, the values of Lieb (10) can be seen to be of the same order of magnitude as those from Keenan and Keyes. Since Lieb has presented a convenient graph of viscosity values for a wide range of pressures and temperatures, as reproduced in Fig. 4, the writers have selected the Lieb chart as the best available reference source. One advantage of the Lieb presentation is that viscosity values are given in terms of English engineering units of pounds per foot-second, which can be readily incorporated into Reynolds number evaluations.

For the purpose of all the calculations in this paper, therefore, the Lieb values determined from Fig. 4 have been used. Fortunately, the deviations between the Lieb values and those from some of the other references do not materially affect the final determination of the friction factor from the Moody chart. For example, for large Reynolds numbers of the order of 10^6, a variation in viscosity of 10%, or even 20%, is of little consequence, since the friction factor is practically independent of Reynolds number. For smaller Reynolds numbers of the order of 5×10^3, a variation of 10% in viscosity would result in a difference of about two per cent in the friction factor, which is not serious. For the condition of laminar flow, in which Reynolds number is less than 2×10^3, the percentage deviation in friction factor would be the same as the percentage variation in viscosity. However, laminar flow is rarely encountered in practical applications, so this deviation can be ignored.

From this review of available material on steam viscosity it appears that additional investigational work would be desirable, particularly in the high pressure region. Viscosity values are of importance not only in fluid flow analysis, but to an even greater extent in the field of heat transfer where a dimensional analysis approach is also used. The fact that viscosity values for wet steam are not available is indicative of a serious omission in this field, although such determinations would involve some difficult experimental problems.

APPENDIX B.

CONSIDERATION OF FACTORS AFFECTING STEAM FLOW AND PRESSURE DROP

Any general solution to the problem of steam flow, as summarized in Charts A and B, must necessarily deal with average flow conditions. Many specific variations from the assumptions used in establishing the average flow conditions were given consideration and will be summarized in the following discussion.

a. Aging of Pipes

The friction factors selected from the Moody chart, Fig. 1, apply to new clean pipes. No general agreement has been reached as to whether a gradual roughening of the pipe surface occurs with a passage of time or whether a smoother surface might result from abrasive wear. In this connection the following four references are of interest, two of which refer to water flow and two to steam flow:

(1) From "The Handbook of Cast Iron Pipes" by Cast Iron Pipe Research Association,
"In attempting to compute the capacity of a pipe line or to figure the probable loss in head after the pipe has reached a certain age, it is absolutely essential to know something about the water conveyed.——In spite of this fact, many of the books and articles on hydraulics and water supply make the bold statement that a definite correction factor must be applied to flow formulas as the pipe increases in age. It is evident that this is incorrect, since, first of all, a large number of experiments have been made that show quite definitely that in many places there is no change whatever in carrying capacities with age. Secondly, assume that a layer of tubercles two inches thick is produced as a result of many years use of a pipe, it is evident that the carrying capacity of a 12-inch pipe would be considerably more reduced than would a 48-inch pipe with the same thickness of tubercles, a fact that is not taken into account in the formulas in common use."

(2) M. S. Carter made a study of the age effect using data obtained from a survey of 385 cast-iron pipes serving in municipal water systems. He determined the increase in friction factor with age in terms of the size of the pipe and the age. For a large pipe the friction factor doubled over a period of twenty years. For smaller pipes the increase was larger. (Hydraulics, by G. E. Russell, 5th ed. Henry Holt and Co. N. Y. p. 187).

(3) From experiments on galvanized-steel pipe of four inches diameter at Lehigh University, Professor Ippen found an increase in friction factor of 20% over a three-year period. (Discussion of Friction Factors for Pipe Flow, by L. F. Moody, Trans. ASME, v. 66, p. 671, 1944).

(4) Professor Keenan found an increase in friction factor of 15% over an eight-months period for steam flow through a one-inch diameter steel pipe. (Friction Coefficients for the Compressible Flow of Steam, by J. H. Keenan, Jour. of App. Mech., pp. A11-A20, Mar. 1939).

Assuming that some amount of increase in friction factor will occur with service, conservative practice would dictate the use of a probable friction factor that might be obtained at some distant date. Any such allowances would be, at best, crude approximations. Furthermore, the piping system would be oversized for an appreciable period of time.

Another alternative would be to design for present conditions, and to anticipate a possible overload on the steam generating equipment in the future. In the case of small heating steam boilers, such overloads could be readily handled. In the case of large steam producers the overload could be met by slight changes in the operating conditions of the boiler. This alternative procedure involves no oversizing of the piping system in the beginning and seems to be the preferred method for practical cases.

b. Economical Pipe Sizes

The following discussion of the relative economy of various pipe sizes is mainly of interest in connection with large installations. From Charts A and B, which are typical in form to those for higher steam pressures, it may be observed that for the same weight flow of steam a small pipe will require a larger pressure drop than a large pipe. On the other hand, the small pipe will require a smaller initial investment. The higher pressure drop accompanying the use of the small pipe will entail an investment in higher pressure steam generators. The final selection of the pipe size will require, therefore, a study of the annual cost of delivery and the annual cost of pipe for a number of pipe sizes.

c. Length of Pipe

Charts A and B do not apply to short tubes that are less than about five pipe diameters. In such short tubes, the friction losses are negligible, while the inertia losses of entrance are predominant.

d. Pressure Drops at Entrance, Valves, Elbows, etc.

In determining the total drop in pressure for a given piping system, all losses should be included. The inertia losses of entrances, valves, elbows, and other fittings can be expressed in terms of equivalent feet of straight pipe. The flow charts may then be used to evaluate the pressure drop of the entire piping system.

e. Steam Quality

As stated in Appendix A, the viscosity values of wet steam are not available. Until such data are established, the pressure drop determined for the saturated condition should serve as an approximation of the actual pressure drop for high quality steam. No analytical method is known for determining the pressure drop obtained from the flow of low quality steam.

f. Heat Transfer Through Walls of Pipe

For the flow process under consideration, the general energy equation for steady flow must also be applicable. When a pressure drop occurs in a pipe due to frictional

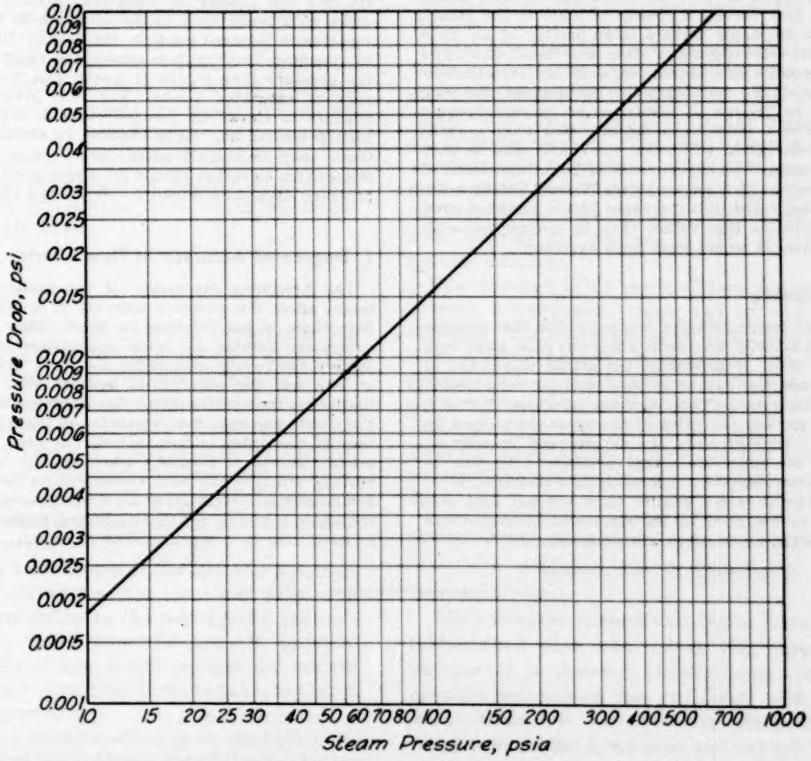


Fig. 5. Pressure drop for 10-ft change in elevation for saturated steam at various pressures.

effects, an energy transformation also takes place; the energy in the form of pressure being transformed into energy in the form of heat. Hence, if no heat were transferred across the boundaries of the pipe the internal energy of the fluid could be expected to increase along the path of flow, since the effect of the pressure drop would be similar to the addition of heat from an external source. Actually some heat transfer takes place across the boundaries, whether or not the pipe is insulated. The heat that is transferred due to the temperature difference between the pipe and the surroundings may be considered as originating from the pressure drop alone, the basis assumed in the formation of the flow Charts A and B.

On the other hand, the heat that is transferred may be considered as originating from all of the energy forms existing within the pipe, including internal energy, PV or flow energy, and kinetic energy. In this consideration any heat transfer serves to lower the total energy level of the fluid, and the resulting pressure drop will be larger than that obtained from the Charts A and B. Hence, when the heat transfer per pound of steam is large, the charts serve as an approximation and the results obtained from the charts will tend to be on the low side. For example, Keenan (Jour. of App. Mech. p. A-11, Mar. 1939) found that by neglecting the heat transfer in the flow of superheated steam through a one-inch *bare* pipe which was 54 ft long, the computed friction factors were from one to 10% lower than the actual friction factors. However, for the same pipe provided with *insulation*, the discrepancy was only about one-half per cent.

For average practical applications, and particularly for heating systems, the flow charts can be considered as sufficiently accurate. For cases involving high rates of heat transfer in which a precise determination of pressure drop is required, the method proposed in the Keenan paper should be consulted.

In some cases the transfer of heat from the fluid to the surroundings may involve a change of state of the steam. The charts do not apply when a large portion of the fluid stream changes from a gaseous state to a liquid state, and quantitative results are obtainable only by experimentation. In general, the safest practice is to avoid this condition, either by the use of insulation or by superheating the steam. Where predictions indicate that only a small amount of condensation will occur, the charts may be used without correction. The experiments of Yellot and Holland (The Condensation of Flowing Steam, Trans. ASME, v. 59, p. 171, 1937) indicated that the vapor phase persisted even below the saturation line, rather than in conjunction with the liquid phase, as would have been expected.

g. Compressibility

The effects of compressibility, which implies that changes in density and velocity will occur along the pipe, have been neglected. In order to determine the actual magnitude of any such change the nature of this internal compression process must be known. That is, if the equation: $P v^n = c$, describes the process the value of the exponent n must be known. It is true that since the density and velocity do change along the pipe, the actual pressure drop will be different from that based on incompressible relations. However, no significant errors greater than one per cent will be introduced by assuming an incompressible flow provided that the following restrictions are observed:

(1) The pressure drop is less than 10% of the initial absolute static pressure. In practice, where long lengths of pipes are involved, this limitation may be observed by subdividing the total length into a number of shorter arbitrary lengths, for each of which the pressure drop is no greater than 10% of the initial pressure at the beginning of the section.

(2) The steam velocity does not exceed about 1/7 of the acoustic velocity. At atmospheric pressure the acoustic velocity of steam is about 1,550 fps; whereas for a pressure of 300 psia the acoustic velocity is about 1,700 fps.

In the majority of practical applications both restrictions are met, so that the charts can be considered as applicable.

For exceptional cases of pressure drops, exceeding about 30% of the initial pressure, the following references are of interest:

(1) A paper by Lobo, Friend, and Skaperdas (Ind. Eng. Chem. v. 34, p. 821, 1942) provides a means of calculating the pressure drop of any magnitude if the exponent n is either known or assumed.

(2) The paper of Hardy and Kemler (HEATING AND VENTILATING p. 43, Aug. 1942) presents a convenient means of correcting the pressure drop determined from incompressible flow relations to conditions of high pressure drops, provided that isothermal flow (n equal to 1.0) is assumed to exist.

h. Vertical Pipes

If the pipe in a given piping system rises to a higher level in the direction of flow, an additional pressure drop is involved equal in magnitude to the product of the density and the change in elevation. Similarly, if the pipe drops to a lower level in the direction of flow, a pressure increase is involved equal to the density times the change in elevation. In Fig. 5 is shown the relationship between the pressure drop per 10 ft length and the absolute pressure of saturated steam. For low pressures or small changes in elevation, the correction is negligible, but for high pressures and large changes in elevation the corrections may be significantly large. Any correction for changes in elevation should be algebraically added to the pressure drop determined for frictional effects alone.

i. Degree of Accuracy in Flow Charts

The preceding discussion of the many variables that might affect the accuracy inherent in a generalized steam flow chart is not intended to show either that the chart values are nothing but crude approximations, or that conversely the results obtainable are of an order of accuracy of, say, one per cent. It is believed that every possible limitation that might affect the accuracy obtainable from the charts has been investigated, and that an over-all accuracy of the order of five to 10% has been achieved. Any greater degree of accuracy when applied to normal engineering practice has been considered to be purely of academic interest. With all of its limitations and restrictions, the chart forms A and B are offered to the industry as a forward step in a much needed direction.

What Would You Do?

Replies to engineering and operating problems of interest to the industrial plant engineer

This Month's Problem

In a line carrying a process fluid, it is important that a check valve be placed to prevent a reversal of flow when the back pressure increases. Some one raised the question that in a pipe line of low fluid flow, better protection at lower cost would be provided by a lift type of check valve as against the swing check. If so, why? If not, when would the use of a lift type check valve be recommended?

WHERE the prevention of back flow is important, it is not only necessary to install a check valve, but to be sure that it is of the type best suited for the service. This month's problem is based on the use of swing check and lift check valves, and the replies should prove of value to many industrial plant engineers.

Perhaps you have a problem relating to industrial plant operation that you would like to see discussed in this department, or perhaps you would like to comment on the problem scheduled for the next discussion. In either case, the editor would be pleased to have you write him. This department is planned to help distribute practical information that might assist the other fellow in his work.

Replies Received

Swing check valves are generally chosen for the same reason as gate valves—because they have free, full unobstructed passage. They are ordinarily recommended for liquid service where maximum volume is required with a steady flow (no pulsations). Ordinarily only a few inches of water column are required to open such valves. Although they are most sensitive, they do require a higher back pressure to seat them tightly due to possible heeling action as compared to lift type check valves.

The lift check valve is one of the simplest and most reliable check because the disc rises and falls in a vertical plane, returning to the seat equally and uniformly over its entire circumference. If properly fitted with a suitable disc, it will be tight and remain so longer than any other type of check valve in almost every range of pressure.

Frequently, the question arises as to the back pressure that is created due to the weight of the disc-holder in such valves. It is true that while it is greater than that of a swing check, nevertheless it does not exceed more than a couple of ounces or two or three inches of water column to unseat them. This is seldom an objection. Only a lift check can be fitted with a light spring to load the disc where conditions necessitate it or where violent pulsations are involved.

The lift check valve has many more advantages than any other check because of its simplicity, tightness, unfailing action, long life and lowest possible maintenance.

Frederick C. Ernst, Chief Engineer
New York, N. Y. *Jenkins Bros.*

The following information is from a valve company engineer who wishes to remain anonymous:

As a general rule, swing check valves are used with gate valves and lift checks with globe valves. In the smaller sizes, the lift checks are a little lower in cost than the gate valve and a little higher in cost in the larger sizes. Over the complete range of sizes, our catalog shows very little difference in prices between the two.

Fluid flow through the valve body of a swing check valve approximates straight line flow and therefore offers less resistance to such flow than would a lift check valve. Swing check valves are widely used for all pressure services. The disc swings freely in an arc from the fully closed position to one providing unobstructed flow. This flow keeps the valve open, and the size of the opening is related to the volume of flow. Gravity and reversal of flow, seat the disc to prevent backflow.

Flow through a lift check follows a turning course through a horizontal bridge wall on which the disc is seated. The disc is seated by backflow or by gravity when there is no flow. It is free to rise and fall depending on the pressure under it. The use of this type is recommended for steam, air, gas, water and general vapor services. Lift checks are made in horizontal globe and angle patterns. Types of this design include automatic stop check, ball disc, vertical and cushioned disc.

Problem to be Discussed

September Issue

The piping department that I have joined has some rubber lined pipe and valves that were installed because of a chemical manufacturing process. My previous experience has not been with such pipe lines. What are the operating precautions to be taken with rubber lined pipe and valves? What kind of inspection schedule, if any, should be followed?

NEWS OF EQUIPMENT AND MATERIALS

Use the prepaid postcard opposite Page 112 for securing additional information on items described in this department.

Vertical Blinds Control Sun, Air

A new type of functional window decoration called the Window Charm vertical blind has been placed on the market by Youngstown Industries, Inc., Girard, Ohio.

The device, made with 3-inch wide adjustable panels of Celanese fabric, is adaptable for home, office, store and institutional installations where it can be used for window coverings, partitions and backdrops.

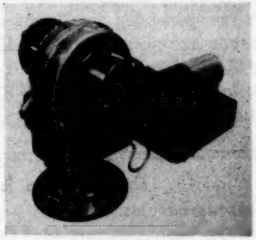
Movement of vertical louvers is controlled by a hidden lever which operates quietly to regulate light, ventilation and privacy.

The vertical design is said greatly to reduce the collection of dirt and dust and when cleaning is necessary all that is required is to slip off the fabric panels, wash and replace them while still wet. No ironing or pressing is ever needed. More than 25 separate colors are offered.

For more information, circle on Inquiry Card, **Item 1**

Oil-Gas Burner for Large Jobs

The answer to gas service interruptions experienced by commercial and industrial consumers during periods of extreme weather in recent winters is its new Twinfuel industrial-commercial combination gas-oil burner, according to Norman Products Co., Columbus, Ohio.



This dual fuel burner is an outgrowth of its domestic conversion burners. It switches automatically from gas to oil and back as determined by an outside thermostat set at the temperature point at which the utility expects service difficulties. Also, the burner can change fuels automatically, depending upon drops or rises in pressure of the gas line.

By permitting normal continuance of heating processes, regardless of weather conditions, the burner enables industries to maintain production schedules without loss to themselves and their employes through shutdowns.

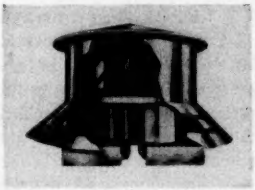
In industrial production heating operations the oil burner can be used for the initial start up of each firing period. As soon as proper stack temperature is reached the gas valve automatically opens, putting positive gas pressure in the gas manifold, breaking the oil burner circuit as soon as gas pressure is established. This insures a positive oil flame for ignition and adequate gas pressure before gas is ignited. Inversely, when gas pressure drops unexpectedly, the oil burner is brought into use immediately and automatically, guaranteeing continued high heat.

Seven sizes are available with capacities from 80,000 to 3,000,000 Btu per hour.

For more information, circle on Inquiry Card, **Item 2**

Quiet Power Ventilator

The Gyra-Flo power roof exhauster, for roof ventilating applications where operating noise must be held to the very lowest level, as in schools, churches, hospitals and theaters, has been developed by Chicago Blower Corp., Chicago, Ill.



An exclusive design incorporating air cut-off guide vanes shears the air off the revolving wheel and forces it out into the atmosphere. These vanes are stationed at cut-off points simulating the scroll design of a centrifugal fan housing and account for the high efficiency of the fan. The discharge cone is designed to permit the air forced off the peripheral edge of the wheel to enter the outside atmosphere with an absolute minimum of turbulence. This, plus the lowest possible wheel tip speeds, keeps the noise level to a minimum not approached by any other exhauster.

Housing can be furnished in aluminum, galvanized iron, copper, stainless steel or any other special metals, and the units are available in belt or direct drive.

Air capacities are from 830 to 29,750 cfm and static pressures from $\frac{1}{8}$ to $\frac{3}{4}$ inches. Noise level is from 61 to 88 decibels.

For more information, circle on Inquiry Card, **Item 3**

Adjustable Flow Regulators

Development of an adjustable flow regulator for cylinder speed control is announced by Waterman Engineering Co., Evanston, Ill. This adjustable regulator gives a constant rate of flow regardless of pressure fluctuations or change in work resistance at any setting within the adjustable range. Adjustable range is 50% of the calibrated flow rate in gallons per minute. It is available for hydraulic systems with operating pressures to 3,000 psi. Line sizes are $\frac{1}{4}$, $\frac{3}{8}$, $\frac{1}{2}$ and $\frac{3}{4}$ inch.

For more information, circle on Inquiry Card, **Item 4**

Oil-Burner Drip Eliminator

A new application of its standard V-5 stainless steel solenoid valve is announced by Skinner Electric Valve Div., The Skinner Chuck Co., Norwalk, Conn. Socony-Vacuum adapted this valve, and combined it with a time delay device, so that the combined unit raises the efficiency and cuts out soot causing smoke in domestic oil burners by regulating fuel flow to synchronize with the moment when perfect combustion conditions are set. This prevents the flow of oil until the oil pressure and fan speed reach their peak efficiency. At this point the valve opens and oil is sprayed suddenly into the fire box already filled with swirling air which readily vaporizes the fuel. The result is proper combustion from the beginning with practically no soot producing smoke.

When the burner stops the valve operates in the reverse, instantly cutting off fuel flow while allowing the fan to operate for a few seconds to allow complete combustion of the oil present in the chamber. No residual oil is left to cause smoking and sooting when the burner starts the next time.

Not only does the valve and time delay device prevent soot accumulation, but it also lowers fuel bills by providing more efficient burning of the oil. Burners equipped with the new valve will not require the annual soot removal job, and owners can expect the solenoid to operate for years with almost no attention.

For more information, circle on Inquiry Card, **Item 5**

Coated Welding Fittings, Joint

Formerly thought impossible, welding fittings and joints for corrosion resistant coated piping are announced by Welstrom, Hamilton, Ohio. At present, mechanical type joints are the only type available for use with internally coated piping systems; failures occur at the joints due to vibration and expansion and contraction. The new fittings and joint are said to eliminate such failures.

The fittings and joints are available in all standard sizes and types of welding fittings and joints from ½ inch up to 30 inches in diameter. With them, the lower cost and construction advantages of welded piping can be enjoyed in piping systems handling many types of corrosive solutions. Turbulence, a prime cause of failure in many types of corrosion resistant piping, is reduced because the fittings have an internal diameter identical with the pipe.

A typical fitting has three parts, an internal sleeve and two external fittings. The joint fittings are welded to the pipe ends and both are then coated with a corrosion resistant type coating. The sleeve is then inserted into the fittings which are then butted together and field welded. This welding destroys the coating both inside and outside the fitting for one-half inch on each side of the weld. On the outside, cold setting coating can easily be applied. Then through a threaded opening in the fitting a cold setting compound is introduced into the interior of the fitting and the opening is sealed with a pipe plug. With this design and application the interior of the pipe and fitting is perfectly flush, fully coated with corrosion resistant material.

For more information, circle on Inquiry Card, **Item 6**

High Pressure Air Diffuser

Embodying several new developments in design, the Kno-Draft high pressure diffuser, Type HPC II, operates at high pressures and velocities, using unusually small, space-saving, exposed ducts of uniform size, according to the manufacturer, W. B. Connor Engineering Corp., Danbury, Conn.

High-induction air mixing results in draftless distribution and permits greater temperature differentials between supply and room air. A smaller volume of sharply cooled air thus provides the cooling effect that would otherwise require a greater amount of air at higher temperature.

The device handles air up to 2,000 fpm, 2 inches static pressure in ducts, and supply air 25 deg colder than room air. Decibel rating at this pressure is 50. The unit may be adjusted, by an externally operated sleeve damper, to discharge any air volume between 90 and 180 cfm without altering the diffusion pattern, or may be completely shut off.

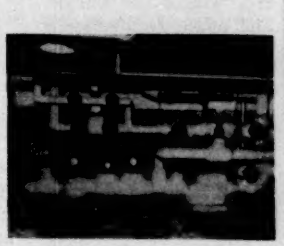
It is especially recommended for department stores and general offices.

For more information, circle on Inquiry Card, **Item 7**

Insulating Cement

An improved mineral wool insulating cement, MW-50, is announced by Philip Carey Mfg. Co., Cincinnati, Ohio.

The new cement is composed of mineral wool pellets, asbestos fibers, bonding clay, and rust inhibitor. As an insulating cement, it is especially adaptable to large, monolithic construction on furnace walls, stills, tanks and boilers. It also works well when used to insulate odd or irregular shaped surfaces, grouped fittings, and process equipment.



The cement can be easily applied with a trowel and bonds well to cold or hot metal surfaces. It is recommended for insulation against temperatures ranging to 1600 deg. A free 5 lb sample bag is offered.

For more information, circle on Inquiry Card, **Item 8**

Bulb Kills Odors with Ozone

A tiny lamp that dissolves odors with a triple dash of ozone, replacing unpleasant smells with clean, mountaintop air, is announced by Westinghouse Electric Corp., Pittsburgh, Pa.

Three times as powerful as the ozone lamp which Westinghouse introduced in 1945, the new Odorout bulb explodes odor molecules in air instantly. This magic-like result occurs as ultraviolet radiations of special wavelength—generated by the lamp—transform the oxygen around the lamp into ozone, an air purifier.

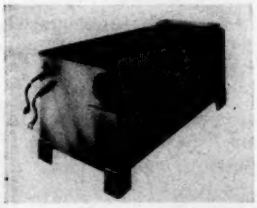
The company said the 3½ watt lamp, when burned in a special wall fixture, destroys cooking, smoking, dampness, mildew and perspiration odors. It recommends its use in kitchens, living rooms, dining rooms, bedrooms, basements, clothes closets and medicine cabinets, and in physican's, dentist's and business offices.

The bulb alone lists at $1.30 and lasts six months when operated 24 hours a day. It must be burned in a special fixture with a current-controlling device such as a transformer. Eight manufacturers now produce special Odorout wall fixtures using one to four lamps in each unit. These range in list price from $6.95 to $18.95, including lamp.

For more information, circle on Inquiry Card, **Item 9**

Industrial Dehumidifier

A new adsorption-type package dehumidifier for industrial applications is announced by Dryomatic Corp., Alexandria, Va. This unit, Model 100, brings portable moisture control within the budget and space requirements of a wide variety of industries and businesses.



The Model 100 unit is a three-channel continuous adsorption dehumidifier with plug-in automatic operation. It is effective singly in enclosed areas up to 25,000 cubic feet. In larger areas, a number of the units can be installed.

The unit can give precise humidity control in a wide range of temperatures—from —40 deg to plus 100 deg. Humidity levels as low as 15% can be maintained.

Measuring 45 inches long, 19 high, and 16 wide, the device is compact and can be used either inside or outside the area to be protected. It is a 110-volt, 60-cycle, single-phase unit, with a maximum power consumption of 1.2 kilowatts. Shipping weight is 210 pounds.

For more information, circle on Inquiry Card, **Item 10**

Internal Pipe Wrench

An internal pipe wrench and easy-out is being manufactured by Clark Brothers Mfg. Co., Hillsboro, Ore. Made in five diameters, the internal pipe wrench can operate under circumstances where any outside wrench is useless.

Among its many uses it allows either the installation or removal of short nipples, without damage to threads, removal of broken pipe from couplings, bushings, faucets, and the like and work against bulkheads, walls or other crowded places where there is no effective room for an ordinary pipe wrench. The smaller sizes may also be used as an easy-out for broken studs. By placing an internal pipe wrench in a vise, plumbers may make short nipples on the job.

Five sizes Clark internal pipe wrenches and an adapter are packaged in a plastic case or they may be purchased individually. They operate with a ½-inch drive ratchet handle, a half-inch flex handle, open end wrenches or others in emergency. Wrench sizes run from ½ inch to one inch.

The head of the wrench is of two pieces of knurled steel one inch long held together by two embedded steel wires. The larger of the two pieces is attached to the shaft and is called the cam. The smaller piece is the follower. In operation the follower slides against the cam surface and is thrown out to the side, forcing both the cam and follower to grip the pipe tightly. All pressure is borne by the cam surface rather than the steel rings. The wrench grips the pipe in the same manner when turned in either direction. Since the wrench fits the pipe internally, pipe flush against walls may be turned as much as 180 degrees without interference.

For more information, circle on Inquiry Card, **Item 11**

Ultraviolet Units for Ducts

An ultraviolet germicidal unit for warm air heating and air conditioning systems has been introduced by D. William Fuller Co., Chicago, Ill. The unit is designed for installation in the cold air return, plenum chamber, or ducts of any air handling system. Principle of operation is to sanitize the constant flow of air to the rooms served. In addition to destroying bacteria, the unit is said to provide a fresh and clean atmosphere through the use of ultraviolet germicidal tubes.

The units are available in six sizes, smallest of which has two 15-watt tubes; the largest, four 36-watt tubes. For additional capacities, the units can be used in combination so that the range covered is from the smallest warm air furnace to the largest air conditioning systems.

For more information, circle on Inquiry Card, **Item 12**

Low Cost Steam Purifier

The first in a new line of low-cost purifiers is announced by The V. D. Anderson Co., Cleveland, Ohio. This purifier is of the internal type and has a wide range of applications inside steam drums, flash tanks, evaporators, packed towers, bubble-cap towers, deodorizers and stills.

Called the Hi-eF purifier, the unit delivers vapor with 1.0 ppm or less of total solids. The manufacturer claims that the unit will pay for itself quickly since (1) in the case of steam from boilers, clean steam means longer life for reciprocating engines and turbines, longer tube life for super-heater tubes and longer operating periods between shut-downs; (2) in evaporator operation clean vapor means greater production, and (3) in food processing clean vapor not only produces a better product but it is essential to good health.

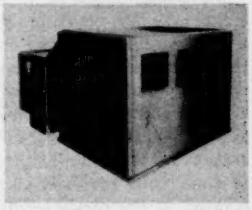
Among other advantages reported are elimination of operating, maintenance and replacements costs. The improved design provides for a self-cleaning action which eliminates maintenance.

The purifiers are available in a complete range of sizes in fabricated steel, stainless steels and other alloy materials. Sizes 4 inches through 10 inches are designed to pass through standard 10 x 16 and 11 x 15 inch elliptical manholes; sizes 12 through 36 inches for standard round manholes; and larger sizes 39 to 72 inches are also furnished upon application.

For more information, circle on Inquiry Card, **Item 13**

Multiple Zone Conditioners

A line of single air conditioning units to meet year-round comfort needs of up to six different zones in a building has been expanded by The Trane Company, La Crosse, Wis.



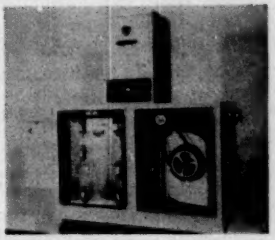
This unit, the Multiple-Zone Climate Changer, uses but one heating coil and one cooling coil to provide full air conditioning for as many as six areas. Each zone has its own control, and receives the conditions it needs without affecting any other zone. It can eliminate inaccurate air conditioning during the in-between seasons. This is because the unit permits gradual change-over from heating to cooling and back again for each zone. Filters and humidifiers enable the unit to do a complete year-round air conditioning job.

Six sizes of the unit provide capacities as high as 23,400 cfm.

For more information, circle on Inquiry Card, **Item 14**

Oil Mist Precipitator

The hazardous problems caused by the fine oil mist emanating from high speed cutting and grinding machine operations can be eliminated by a new oil mist precipitator developed by Trion, Inc., McKees Rocks, Pa. Design of this equipment is based on the electrostatic precipitation principle of attraction.



Oil mist from machining operations is charged as it passes through an electrostatic field and is then attracted to plates of opposite polarity from which it eventually drains into a collecting pan for ultimate reuse. Under normal operations, daily oil recovery may be as great as five gallons.

The precipitator offers a number of outstanding advantages, among them being protection of machinery and factory interiors such as walls, floors, and ceilings from oil mist, which tends to coat these interior surfaces, creating a possible fire hazard and necessitating frequent cleaning. Another advantage is elimination of unhealthful effects of oil mist on the machine operator. Machinery hoods for exhausting the oil mist to the outside atmosphere are eliminated and at the same time air pollution is prevented.

The precipitator is constructed of heavy sheet metal and is adaptable for floor mounting or overhead ceiling suspension.

For more information, circle on Inquiry Card, **Item 15**

Expands Insulation Line

Several new items have been added to its different types of multiple accordion aluminum insulation by Infra Insulation, Inc., New York, N. Y.

Recognizing that a significant saving can be made in many building projects where some less than 16 inch center spacing is to be found, the company is now offering Type 6, Type 4, and Type 2 for 12 inch centers in addition to the standard 16 inch, as well as Retardive insulation for 8, 16, and 24 inch centers.

Where in-between widths are needed, one has merely to fold over one or more of the accordion pleats, thus making the insulation narrower. It can easily be made wider, any width, by stapling two or more pieces of insulation together.

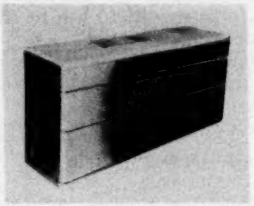
Another innovation is the making of 1,000 sq ft of the Type 4 insulation for 16 inch centers in one continuous piece, 750 linear feet. The one 24 inch insulation strip of 1,000 sq ft is 500 linear feet. All one need do is to cut with a shears or snips as it is needed, gradually unfolding the entire 1,000 sq ft from one carton.

Type 6, 24 inch, is a new line which is available for wider spacing of building units than the conventional, and is used in ceilings and roof spaces. Type 4, 24 inch, has always been produced.

For more information, circle on Inquiry Card, **Item 16**

Conditioner for Hospitals

A hospital operating room air conditioning unit designed for operation in hazardous gas atmospheres has been introduced by The Trane Company, La Crosse, Wis.



Safety provisions in the design include provision for drawing 100% of the conditioned air from the outside, and adequate coil and humidifier capacity to permit wide latitude in the precise control of both temperature and humidity throughout the year. The hospital unit has an explosion-proof motor and sparkproof fans, fan belts, wiring and switches.

The units are made in four sizes, with capacities from 200 to 800 cfm.

For more information, circle on Inquiry Card, **Item 17**

Refrigeration Insulation

Development of a new and improved series of Fiberglas insulation for refrigerated equipment, designated as the 500 series, is announced by the Building Materials Div., Armstrong Cork Co., Lancaster, Pa. The most important of the former 600 series of Fiberglas insulation will be replaced by the new material.

Manufactured by Owens-Corning Fiberglas Corporation, the new insulation was made possible through the development of improved production equipment so that fiber sizes could be reduced. The 500 series is marked by its uniformity, smoothness, and additional resilience, giving marked improvement in conductivity and performance.

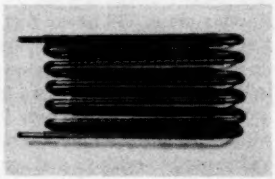
Comparing the new series, at 75F mean temperature, with the former 600 series, PF-511 has a *K* factor of .250 while the former PF-611 *K* factor was .260; PF-512 has a *K* factor of .240 while PF-612 had a *K* factor of .250; PF-513 has a *K* factor of .225 while PF-613 had a *K* factor of .240.

Remaining in the line in the 600 series will be 614, 615, and 617, which are primarily used for sound deadening and load bearing.

For more information, circle on Inquiry Card, **Item 18**

Spined Heat Transfer Surface

An extended heat transfer surface made by a process which mechanically lifts material from the parent metal of the tube, permitting the resulting spines to remain attached as an integral part of the original tube, has been introduced by Heatron, Inc., York, Pa.



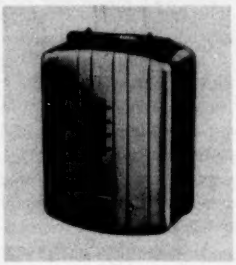
Sufficient wall thickness is allowed in the original tube to provide for the secondary surface (spines) and still maintain suitable wall thickness of the primary surface after spining.

Applications of the surface include oil cooling, oil heating, domestic water heating, hot water boilers, vapor condensing, compressed air cooling and so on. The surface is made in sizes from ⅛ to 1¼ inches, inclusive, in copper, steel, aluminum, stainless steel, cupro-nickel and Inconel.

For more information, circle on Inquiry Card, **Item 19**

Duplex Low Voltage Thermostat

For two-position control of motor-operated valves, pumps, relays, and other heating system components, Barber-Colman Co., Rockford, Ill., has developed a low voltage duplex thermostat to maintain reduced temperatures for night or non-occupancy periods of system operation.



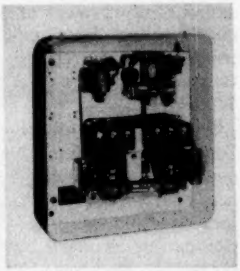
Control is changed from one thermostatic element to the other by automatic time clock or manual switch. Control settings are easily varied from 45 to 75 deg for night, and 55 to 85 deg for day operation. Stops inside the case can be set to limit or lock control settings. Differential is 1½ to 2 deg.

Snap action switches with fine silver contacts are single pole, double throw. Thermostat is enclosed in a champagne gold finished metal case.

For more information, circle on Inquiry Card, **Item 20**

Washing Machine Control

A new laundry washer control panel, Bulletin 723, for use with squirrel-cage motors driving washing machines used by laundries and dry cleaners, is announced by Allen-Bradley Co., Milwaukee, Wis.



The washers consist of a large cylinder rotating in a shell containing water or cleaning fluid. To prevent snarling and tangling of clothes, the washer cylinder is operated in one direction for a certain length of time, then reversed and rotated in the opposite direction for the same length of time. A dwell period is provided between the reversals of the machine.

These panels contain the necessary control equipment to perform this reversing and dwell function. They provide four reversals per minute with an adjustable dwell period. Panels are supplied for two wire control, operated from a maintained contact push button; or three wire control, used with a momentary contact push button.

For more information, circle on Inquiry Card, **Item 21**

Wind Velocity Recorder

A new wind velocity recorder is announced by Hastings Instrument Co., Inc., Hampton, Va. The unit provides both instantaneous indication and a strip chart record of wind velocities between 0 and 200 miles per hour. The entire instrument, with the exception of the pick-up head, is incorporated in a rugged recorder unit. It is a dual range instrument; Range 1 is from 0 to 50 miles per hour and Range 2 is from 5 to 200 miles per hour. Velocity indications are made by a pen moving across a logarithmic scale.

Instrument is furnished for use with either a directional or a horizontally non-directional probe. These probes are the thermopile type and have no moving parts. The probes are temperature compensated to eliminate effects of temperature and rate of change of temperature.

The recorder is especially suitable for applications requiring accurate recording of wind velocities over long periods of time.

For more information, circle on Inquiry Card, **Item 22**

Horizontal Oil Furnace

An oil-fired horizontal winter air-conditioner furnace with 80,000 Btu per hour output has been developed by Armstrong Furnace Co., Columbus, Ohio, and Des Moines, Iowa. The new unit is now in production. Christened as Model 8801 L8-80, the unit is equipped with a new burner (called the D4) designed for low-gallonage efficiency. The heating element, designed for oil, is of welded steel and incorporates a wrap-around radiator. Steel fins are welded to the top of the furnace body to gain additional heat transfer in the horizontal position.

The furnace is shipped in a crate which will pass through standard doors, and only the burner and combustion chamber need be installed by the dealer. Return air may be brought into the front, rear or end of the blower compartment. To accomplish this without excessive installation labor, openings to fit the filter frame are provided in all three locations. The filter frame is placed in any of these, the blower compartment access door in another, and an enameled steel panel in the third. All are interchangeable.

Measuring just 24 x 24 x 72½ inches, the steel cabinet is finished in the standard two-tone blue enamel.

For more information, circle on Inquiry Card, **Item 23**

High Pressure Gate Valves

A forged steel gate valve, designed for the high pressure field, is announced by Reading-Pratt & Cady Div., American Chain & Cable Co., Inc., Reading, Pa. Among its features are a bolted bonnet which insures maximum service life and low-cost maintenance, tongue and groove joint with soft iron gasket to assure tightness under varying service conditions and extremely hard wedge facing that minimizes seizing, galling and abrasive wear. Stainless steel gland bolts and nuts prevent freezing or corrosion while the two-piece gland and follower applies uniform pressure on packing—will not bind on stem.

The valve is available in sizes of ¼, ⅜, ½, ¾, 1, 1¼, 1½, and 2 inch.

For more information, circle on Inquiry Card, **Item 24**

Vertical Condensate Unit

Compactly designed to occupy a minimum of floor space, a vertical condensate return unit has been introduced by Roy E. Roth Co., Rock Island, Ill. The units are versatile for applications up to 8,000 sq ft EDR at 20 psi. Two sizes cover this range.

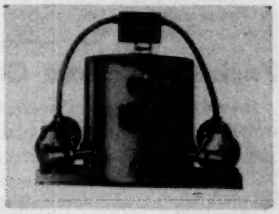
The unit handles water to 210 deg without vapor lock. The vertical design is particularly intended for installations where the return piping is close to the floor level. Also, the unit can be installed in a shallow pit, when desired, without risk of flooding the motor, which is mounted vertically above the pump and receiver.

The unit is supplied as a complete assembly including pump, choice of cast iron or steel receiver, 10 or 15 gallon, enclosed float switch, single phase or 1750 rpm three-phase motor.

For more information, circle on Inquiry Card, **Item 25**

Duplex Condensation Units

A complete line of duplex condensation return units is now available from Decatur Pump Co., Decatur, Ill. These units have been designed for applications where a standby pump to insure continuity of operation is advisable.



Two Burks Super Turbine pumps are mechanically alternated by a positive float operated switch mounted on top of the receiver tank. The switch has the added feature of automatically operating both pumps at the same time under peak load conditions.

Factory assembled units are made in 14 sizes to meet most installation requirements up to 100 psi. The receiver tank is constructed of heavy gauge copper bearing steel and the entire assembly is mounted on a steel base. For larger duplex installations up to 150 psi, assembly is made on the job using Burks independent series pumps with the tank and alternator switch.

All ratings have a 3 to 1 factor of safety which affords ample reserve for overload conditions.

For more information, circle on Inquiry Card, **Item 26**

Quick Repair to Concrete Floor

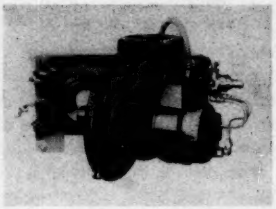
Permanent repairs to chuck holes or breaks in concrete floors can be made easily and quickly during working hours by using Por-Rok quick setting cement, according to the manufacturer, The Hallemite Mfg. Co., Cleveland, Ohio. Patches can be installed during lunch or rest periods.

Application of the compound is fast and simple. Merely clean out the hole or break, mix the compound with water, and pour into the opening. The material is self-bonding, will not shrink, and requires no troweling for a perfect finish. The patch is ready for light loads in 15 minutes, normal trucking in 30 minutes, and heaviest loads within one hour.

For more information, circle on Inquiry Card, **Item 27**

Heavy Duty Oil-Gas Burner

The Heavy Duty combination oil and gas burner is being marketed by S. T. Johnson Co., Oakland, Calif., and Philadelphia, Pa. With this burner it is possible to change from one fuel to the other by throwing a switch. Users can burn the fuel that is most economical and available, without loss of efficiency, and without any interruption of operations. They are available in sizes ranging from 20 to 400 hp, equipped for manual, semi-automatic or fully automatic operation, and with electronic type combustion safety controls.

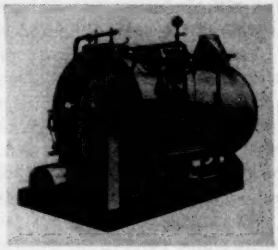


These burners will operate on No. 2, No. 4, No. 5 or No. 6 fuel oils and on natural, manufactured or sludge gases of varying heat contents and pressures. They may be swung out of firing position without using a gas swivel and without disconnecting oil or gas pipe lines.

For more information, circle on Inquiry Card, **Item 28**

Packaged Steam Generator

Introduction of the Ticosteam Generator, a packaged steam power plant, to a broad field of applications is announced by Titusville Iron Works Co., Titusville, Pa. The generator is a completely assembled unit, finished, tested, and certified at the factory. Operation is fully automatic, with all controls contained in a single push-button-controlled station.



Mounted on a steel skid, the generator may be installed on level and solid floors without foundation construction. When service connections are made to fuel, water, steam and electrical supplies, the unit is ready for operation. No stack is required; a vent through the roof is sufficient.

Available in a full range of sizes, the generators are designed for light oil and combination light oil and gas, heavy oil and combination heavy oil and gas, and for straight gas operation.

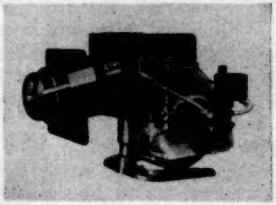
Safety features include a Fireye combustion control head with alarm provision; thorough purge before ignition, and also after combustion; dual low water cut-off; interlocking safety switches on pilot and main gas lines; motorized main gas valve; high pressure gas regulator; and gas-electric ignition. All safety features are designed, in case of power breakdown, to fail in a safe position.

Bulletin B-3100 is available.

For more information, circle on Inquiry Card, **Item 29**

Combination Gas-Oil Burner

The Bankheat combination oil and gas burner is being marketed by S. T. Johnson Co., Oakland, Calif., and Philadelphia, Pa. It is intended for industrial, commercial and residential installations.



The burner is changed from oil to gas or gas to oil by flicking a switch, but an automatic control to make the change-over is also available.

When burning oil, with the fuel selector switch set in the Oil position, the oil fuel is pressure-atomized and mixed with fan-driven air to form a spray that burns with a soft flame. With gas, snapping the fuel selector switch to the Gas position opens a by-pass valve in the oil pump and connects a slow-opening type magnetic gas fuel valve into the control circuit. The gas is premixed with air in the gas head and this mixture is then delivered into the rotating air stream as it leaves the burner nose.

The burner is made in 7 sizes with oil burning rates from 2¼ to 18 gallons per hour and from 315 to 2,520 cubic feet of 1,000 Btu gas per hour.

For more information, circle on Inquiry Card, **Item 30**

Air Vent Valve Improved

A new improved air vent of the expansion type (Cat. No. 72) for baseboard, convector and free standing radiation on hot water heating systems is announced by Maid-O'-Mist, Inc., Chicago, Ill. The advantages of being able to clean this valve in the field have been retained but the new design eliminates the possibility of tampering. The cap can be removed with a large screw driver by the trade for cleaning if necessary, but removal is impossible without a tool.

Due to the siphon tube incorporated in the design, fast, automatic and positive operation results when installed in either the vertical or horizontal position.

For more information, circle on Inquiry Card, **Item 31**

PRODUCT INFORMATION SERVICE

Use the postage-free postcard below for further information on:

- **News of Equipment and Materials**
- **New Catalogs**

Circle the Item Numbers in which you are interested and print clearly your name and address with title.

NEW CATALOGS

ARRESTORS FOR SPRAY BOOTHS

If You Spray Paint We Can Help You is the title of Form 1167, a 12-page booklet issued by Research Products Corp., Madison, Wis. In it are described the many ways R-P Paint Arrestors can be used to simplify the difficulties frequently encountered in the installation and maintenance of paint spray booths. Typical installations are described and illustrated, including the use of the paint arrestor if a water wash spray booth is used, if no paint arrestors are used, if replaceable paint arrestors are used, and if cleanable paint arrestors are used.....Item 32

GOVERNMENT BUILDING DRAINS

Catalog GS-2, illustrating and describing its products which comply with U. S. Government specifications, is issued by Josam Mfg. Co., Cleveland, Ohio. It is a ready reference guide for use by architects, engineers, plumbing supply wholesalers, plumbing contractors, and others responsible for the operation and performance of plumbing drainage products in government buildings and marine construction. ..... Item 33

ROOF VENTILATORS AND LOUVERS

A new, condensed catalog covering its complete line of roof ventilators and louvers is available from The Burt Mfg. Co., Akron, Ohio. It supplies design and construction features for each ventilator type plus mounting and flashing details; performance, dimension and weight data. Basic information on dampers, bases, industrial louvers and general purpose louvers is also included. ..... Item 34

FIRE-SAFE DRAWING CABINETS

Engineering tracings, drawings and specifications are vital records which must be protected. A handbook, SC 688, which points the way to maximum protection for engineering drawings is entitled How Safe Are Your Drawings? and is available upon request to Remington Rand Inc., New York, N. Y. It states that according to past experience, fire is one of the most destructive tools used by saboteurs, and shows the fire-resistant protection drawings need. .....Item 35

COOLING DEVICE FOR CALIBRATION

Three models of Belmont Hilsch vortex tubes are catalogued in a leaflet, Form V-2-551, published by Thermo Instruments Co., Belmont, Calif. Text describes the use in these devices of an internal vortex to separate a flow of compressed air (or other gas) into hot and cold fractions which can be used in a wide variety of ways for calibrating instruments, cycle-testing equipment, cooling thermocouples, etc. Operating-characteristic curves are provided to show temperature drop below that of inlet air over a range of 15 to 82F and rate of flow for various input pressures. Specifications are tabulated and prices listed. .....Item 36

HEAT-RESISTANT PAINTS

A new Bulletin, L-4261, descriptive of its complete line of heat-resistant paints, is announced by Speco, Inc., Cleveland, Ohio. It gives application and product data for the company's five heat-resistant paints. ..... Item 37

MOTOR DATA

A 4-page catalog on its single phase, polyphase, and direct-current motors has been issued by Wagner Electric Corp., St. Louis, Mo. One page each is devoted to single phase, polyphase and squirrel-cage motors, and capacity application data and illustrations are included. ..... Item 38

WET BASE BOILER

A 4-page catalog, Form AD-1849, has been issued by Crane Co., Chicago, Ill., devoted to its Crane 14 boiler for oil, gas, coal or coke. This is a wet base boiler with extended jacket for residential applications. Units are described, illustrated, and accompanied by capacity and dimensional data. .....Item 39

LIQUID CHILLERS

A new two-page, two-color specification sheet, Bulletin 50-A Rev., is now available on its Flow Cold liquid chiller made by Acme Industries, Inc., Jackson, Mich. The sheet illustrates the single and dual compressor units and also shows the finned coils, convectors and cooling towers which the company manufactures. Specifications, dimensions and weights are given and ratings for all models are provided. ..... Item 40

STEAM TRAP MANUAL

A 24-page catalog, Bulletin T-1740, entitled Steam Traps, has been issued by Yarnall-Waring Co., Philadelphia, Pa. Most attractively prepared, it answers the question as to why use a steam trap and describes the advantages and method of operation of the Yarway trap and includes figuring of size, capacity chart, dimensions, applications, prices, installation and operating suggestions, instructions on ordering. .....Item 41

PIPE HANGERS AND BRACES

Catalogs 501 and 502 have been issued by Bergen Genspring Corp., New York, N. Y., the former being devoted to the company's line of variable support pipe hangers, the latter to the company's non-resonant sway braces.....Item 42

MANUAL ON PERIMETER HEATING

Distribution of a condensed manual, worksheet and a photographic story on perimeter radiant warm air heating is announced by Mor-Sun Furnace Div., Morrison Steel Products, Inc., Buffalo, N. Y. The manual and worksheet, Bulletin 51-7-A, contains suggested design procedure and construction details for radiant warm air heat — perimeter or spider systems — for single story slab-on-ground houses of not more than 60,000 Btu per hour heat loss. It contains typical heating system layouts, charts for measuring heat loss, warm air register sizing, return air branch and intake sizing, floor edge loss factor, register delivery in Btu per hour, return air sizing table for room grilles and connecting duct, floor plans, return air plenum construction, furnace installation, engineering furnace data, slab construction, site, underslab preparation, insulation, installing slab ductwork, installing furnace and controls, balancing registers.....Item 43

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BASEBOARD HEATING

Form AR-296C, in 4 pages and 4 colors, has been issued by U. S. Radiator Corp., Detroit, Mich., and describes for the layman its radiant baseboard. ..... Item 44

OIL BURNING MANUAL

A 4-page manual, Form OBM-514H, entitled Oil Burning Manual of Information, has been issued by Cleveland Fuel Equipment Co., Cleveland, Ohio. Among 20 selected subjects covered are air flow through airports, available draft, excess air, boiler pressure and flue gas temperature, and similar subjects for which formulas and tables are given. The manual concludes with a description of the company's damper control for commercial and industrial boilers. .....Item 45

HOW TO HEAT HOUSES

An elaborate 24-page booklet, Form SA 1500A, entitled 10 Ways to Heat Your New Home, has been published by Minneapolis-Honeywell Regulator Co., Minneapolis, Minn. Intended for the consumer, it briefly but thoroughly describes the different methods of heating houses, including not only the older methods but perimeter warm air systems, radiant heating water systems, and heating from the sun. Included is a page of Do's and Don't's for the consumer in planning for his heating comfort. ..... Item 46

WARM AIR DUCTS

A 4-page folder, comprehensively illustrating and describing its line of Sonoairduct, has been issued by Sonoco Products Co., Hartsville, S. C. These ducts are laminated fiber tubes which, when embedded in concrete, may be used for supply or return lines for perimeter warm air heating installations.....Item 47

VACUUM AND CONDENSATE PUMPS

Twenty pages of informative material on vacuum and condensate pumps make up Bulletin 1401, recently released by C. A. Dunham Co., Chicago, Ill. The first part of this booklet covers vacuum pumps, ranging from 2,500 to 65,000 EDR. Included is an illustrated description of vacuum pump operation, detailed information on working parts of the pump, a table showing standard air and water capacities, rating and testing procedures, a typical specification sheet, diagrams of sample pump installations, and tables of dimensions and weights. The section covering condensation pumps, ranging from 2,000 to 50,000 EDR, describes the advantages of this pump for rapid return of condensate to low pressure boilers. The pump's simple operation is illustrated with a keyed cut-away drawing. Also given are capacity tables and a typical specification sheet.....Item 48

ENCYCLOPEDIA ON SOLDER

An educational brochure on the nature, properties, and uses of solder, 36-pages and first of its kind on the subject, is announced by Federated Metals Div., American Smelting and Refining Co., New York, N. Y., under the title Solder.

Separate sections are devoted to thermal effects, mechanical properties, principles of soldering, and fluxes. Next, the selection of the proper solder for a job is explained, fusible alloys, a group of alloys with low melting points, are described. Following a list of practical applications and a comprehensive description of all Federated solders is a resume of specifications and technical data. This section includes the melting range of tin-lead solders; ASTM, SAE, Federal, and Military specifications, as well as wire tables. Although published by a commercial metals firm, this catalog is basically an editorial treatise and is a valuable addition to any library. Text is broad and unbiased. .....Item 49

VALVE PIPING TIPS

A useful sheet of illustrated tips on valve piping is available upon request from Barber-Colman Co., Rockford, Ill. This sheet, F-4774, illustrates installation hints for fitters and plumbers.....Item 50

POWDER-POWERED TOOL

Three 4-page catalogs have been issued by Powder Power Tool Corp., Portland, Ore., and devoted to its powder power tool for fastening steel, wood, or composition materials instantaneously to steel, concrete, brick or masonry. One catalog is devoted to applications for the tool and the tool itself, while the others carry drivepins and accessories.....Item 51

COOLING EQUIPMENT CATALOG

Publication of its new refrigeration equipment catalog, No. R-225, is announced by Kramer Trenton Co., Trenton, N. J. Numbering 52 pages, it is the largest catalog ever published by this company and includes illustrations and drawings of all its products. An engineering section permits rapid selections for 35F temperatures as well as for low temperatures of 0F to minus 20F. The maker's condenser line, enlarged to include cooling towers and remote-type air-cooled condenser extended up to 10 ton per single unit, is described. Also included are data on units for walk-in boxes, comfort cooler for low cost air conditioning, and the Thermobank line.....Item 52

TEXTILE AIR CONDITIONING

Basic methods and principles of modern textile mill air conditioning for efficient economical mill operation are presented in graphic form in a manual released by Carrier Corp., Syracuse, N. Y. It underscores the intensified present-day need for temperature and humidity control as a result of rising labor costs, new high speed precision machinery, and increasing use of synthetic fibers, and explains the functioning of central station, atomizer, and combination systems. It describes application of air washers, refrigeration and other equipment in producing the desired conditions, and of heat diffusers and fans in dyehouse ventilation. ..... Item 53

ESTIMATOR FOR BASEBOARD HEAT

A simplified, rule-of-thumb method for estimating approximate heat losses, radiation requirements and materials costs for Radiant-Ray baseboard heating is one feature in the new, revised Easy Estimator, published by Radiant Baseboard Panels, Inc., New Britain, Conn. Other features include simplified installation data; handy forms for computing individual room requirements; a special form for summarizing over-all costs; price lists and a chart showing how to effect substantial savings in piping costs. In addition to serving as a reference source and work sheet, the new Estimator becomes a complete data file for each job installed or quoted by the contractor. Duplicate summary sheets provide a permanent carbon copy record of materials ordered from the supplier...Item 54

MOTOR STARTING SWITCHES

An 8-page Bulletin 600 on its manual starting switch for fractional horsepower motors is offered by Allen-Bradley Co., Milwaukee, Wis. It describes the new starting switch in detail and is illustrated with photographs of typical installations. It also contains complete dimensional and engineering data, describes and illustrates outstanding features of each of the six switch models and a wide variety of standard enclosures for all service conditions. Among the switches shown is a key-operated model for both open and closed types, useful where unauthorized operation of the switch is to be prevented. Enclosed models for hazardous locations are also featured.....Item 55

CLAY PIPE, CHIMNEYS, SEPTIC TANKS

A condensed four-page bulletin, R-751-6, of particular interest to architects, contractors and builders has been published by The Robinson Clay Products Co., Akron, Ohio. It details and illustrates vitrified clay pipe, perforated clay pipe, Skip-Pipe, Staminite pipe, clay liner plates, clay flue lining, chimney tops and bases, vitrified clay meter boxes, Lap-Lok wall coping and septic tanks with burned-in baffles. .....Item 56

TEMPERATURE CONVERSION CHART

Publication of an easy reference chart, for use in converting temperatures, is announced by Stevens Mfg. Co., Inc., Mansfield, Ohio. Printed in two colors on stiff plasticized board, and 3-hole punched for use in binders, the chart can be used to convert temperatures from 70 to 650 deg., either Fahrenheit or Centigrade. Reverse side lists major types of Stevens thermostats and their applications. ..... Item 57

PLEASE SEND US MORE INFORMATION. Circle below item numbers on which you wish further information.

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57			

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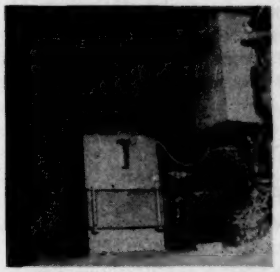
PRODUCT APPLICATIONS

New, Unusual, or Ingenious Uses of Equipment and Materials

Electric Cable Heats Homes

PROBLEM: In many homes in and around the Columbia River power area, the problem of heating intermittently and with precise control is more serious than in areas where outside temperatures are more extreme.
SOLUTION: The Electradiant system, developed by R. S. Tice, of Monterey, Calif., was devised to meet the particular conditions of the area. The system consists of a special processed steel cable designed for uniform conductivity and absence of hum. An insulation strip is placed around the perimeter of the foundation to form a floating slab. Vermiculite concrete is used for lower layers of the slab. Dwellings are insulated to transfer about 8½ Btu per (hr) (sq ft) of exposed surface at design temperatures. A special thermostat was developed that has a tolerance range of 0.1 degree. This thermostat is in series with a timing device which limits operation of the pilots and heating circuit to within five seconds. Cable is laid in sinuous panels on 5 to 12 inch centers, depending on the heat requirements. A heating transformer supplies low voltage and high current to the grids. A grid thermostat limits the temperature of the panel to a pre-set level. The grid and room thermostats are in series.



RESULTS: More than 500 homes have been equipped with the system using from one or two to twelve or fifteen circuits each. Cost of operation varies between eight and eleven cents per square foot of heated surface per year at a .016 per KW basic heating rate. The system has been adapted for both concrete and wooden floors.

Largest Turbine Pumps for New York City

PROBLEM: The increasing shortage of water shipped to New York City owing to multiplication of demand has resulted in the construction of an emergency pumping station which will require pumping capacity sufficient to move 100 million gallons a day of Hudson River water against a 575-ft head. This water will be mixed with seven times its volume in upland water shed water.
SOLUTION: To meet specifications for operation at any head between 525 and 625 ft, Peerless Pump proposed six of its vertical close coupled turbine type pumps, the largest of the type ever to be manufactured. Of these six units, five would carry the full load of 100 million gallons a day. Each has a capacity of 20 million gallons a day at a head of 600 feet. These pumps have five 36-inch diameter bowls with discharge of 24 inches in diameter. Synchronous electric motors, direct connected to the pump, are rated at 2,500 hp each and operate at 900 rpm on three-phase, 60-cycle current at 4,000 volts. Motors were manufactured by General Electric.

RESULTS: The Peerless organization designed and built the pumps ready for first testing operation in six months. Tests showed pump efficiency requirements were exceeded by 8 to 12%. Pumps operated at about 85% efficiency.

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18 Verticals Heat Two Acres

PROBLEM: The indoor practice building of the University of Minnesota, used for baseball, football and track practice during the winter, is a structure 200 x 400 feet covered by a semi-cylindrical roof without interior posts or supports of any kind. Fifteen trusses span the width. Tops of the trusses are 64 ft above the floor. The calculated heat loss is 6.5 million Btu per hr.
SOLUTION: Mounted 40 ft above the dirt floor, 18 Modine vertical unit heaters cover almost two acres with a blanket of warm air. Steam from the central heating plant is reduced from 90 to 5 lbs per square inch before delivery to the unit heaters. Six V-2010 and twelve V-1360 are mounted in three rows down the length of the building and are equipped with cone-jet deflectors. They are operated by manual controls so that each heater is independent, an advantage when only a portion of the field is in operation.

RESULTS: Area and degree of heat in a large building can be controlled without interference with practice measures.

Light Centrifugal Eases Water Problem

PROBLEM: At new laboratories constructed for General Railway Signal Co. in Rochester, complete air conditioning was specified, and design was based on a preliminary survey indicating ample ground water supply. Before the building was completed, it was established that available well water was not cool enough for the purpose.

SOLUTION: Both steam and electricity were available, but space for heavy equipment had not been allowed in original plans because of reliance on well water. The only available space for refrigeration equipment was on the roof directly over the offices. Owing to its light weight and compactness, a Trane CenTraVac was selected and installed over the offices, in a small penthouse which also houses a Trane air washer and fan.

RESULTS: The sound from the centrifugal refrigeration unit was unnoticeable in the office below owing to vibration-free operation. The machine includes an automatic capacity unloader so that personnel may work in various parts of the building during evenings and weekends without excessive demand on the system.

Solving a Re-Insulating Problem

PROBLEM: At the John Sexton Co., a large wholesale grocer in Chicago, several refrigerated rooms required re-insulating. In one room operated at —10F, some of the wood structural members were in poor condition and required replacing.

SOLUTION: Insulation was removed from the underside of the overhead wood deck and from around the supporting wood joists. After the wood had been repaired, slots were cut around the perimeter of the ceiling and insulation was applied on the top of the wood deck. A finished concrete upper floor was then poured over the insulation. Two layers of 3-inch Armstrong Corkboard were applied with hot asphalt to repaired sections of the wall. Structural joists were insulated for a distance of approximately three feet in from the walls using cork belts, two layers of 3-inch corkboard applied in hot asphalt.

RESULTS: Under an unbroken insulation barrier, the wooden decking remained open for drying and inspection. Poured concrete floor above the freezer can be used for regular storage space.

Industrial Heaters for School Hall

PROBLEM: Intermittent heating and ventilating of school assembly halls poses a serious problem for designers where economy of installation and operation frequently are primary considerations.

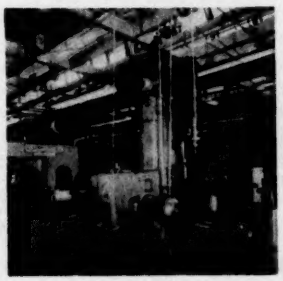
SOLUTION: At the E. Rivers School in Atlanta, Ga., two Dravo industrial type direct-fired warm air space heaters were installed. Heating and ventilating needs of the auditorium are handled by one of the Counterflo units with an output of 500,000 Btu per hour. The kitchen and cafeteria are heated by another Dravo heater with the same output. Both heaters are positioned horizontally and concealed in the structure. The auditorium heater is placed in a false ceiling above the stage with its outlet discharging through two ducts leading to ceiling diffusers. Return air is drawn from floor level in the auditorium into a grille opening under the stage floor. Fresh air is blended with recirculated air before entering the base of the heater.

RESULTS: For intermittent operation, the Dravo heaters have been found to be economical in handling both ventilation and heating.

Coolant Chiller Speeds Production

PROBLEM: Production of motor cylinders at the Reo Motor Company, Lansing, Mich., was being delayed by numerous inspections to assure exacting tolerances. Additional production time was lost because honing machines had to be shut down to enable the coolant to cool.

SOLUTION: A 15-hp Acme Flow-Cold Chiller was installed near two honing machines. Because of space limitations, it was suspended from the ceiling above the machine. The chiller cools 40 gallons per minute of coolant from 90F to 70F. In each suction line, valves were installed to balance the flow of oil from each unit, equalizing the amounts of oil removed from each machine.



RESULTS: The coolant cooled to proper temperatures enabled the honing machines to be operated for longer intervals. Production also was increased because the honing machines did not run "hot" and maintained close tolerances without the need and delay of frequent inspection.

Abstracts AND Reviews

Publications abstracted in this department should be ordered direct from publisher.

AIR CONDITIONING IN SUMMER AND WINTER

Unlike many books that have been written on air conditioning, Air Conditioning in Summer and Winter (2nd edition), by Richard E. Holmes, was prepared for students with a secondary school technical education. Originally, it was based on lessons given by Mr. Holmes to students at Westinghouse preparing for the air conditioning industry.

The author, at the time of the first edition, was design engineer with Westinghouse Electric Corp. At present, he is chief engineer, Air Conditioning and Refrigeration Division, Worthington Pump and Machinery Corp.

The principles and methods of air conditioning are clearly explained, and a sound grounding of essential information is made available.

Some of the 23 chapters in the book cover psychrometry, requirements for comfort, air conditioning systems, winter air conditioning, heating systems, humidifiers, air filters, application of winter air conditioning equipment, refrigeration principles, refrigerants and refrigerant tables, refrigeration systems, compressors, condensing equipment, low side equipment, dehumidifiers, field assembled systems, self-contained air conditioners, application of summer air conditioning equipment, and temperature and humidity controls.

Material of the first edition has been thoroughly revised and the book has been expanded to include new chapters on reciprocating and centrifugal compressors, low side equipment, panel heating systems, packaged air conditioners, and dehumidifiers.

Air Conditioning in Summer and Winter, by R. E. Holmes. Cloth bound, 6 x 9 inches, 352 pages. Published by McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York 18, N. Y. Price, $5.75.

TECHNIQUES OF PLANT MAINTENANCE

The papers and discussion of the papers presented at the technical sessions held in conjunction with the Second Plant Maintenance Conference at Cleveland this year is now available as a cloth bound volume. Last year the proceedings were available in mimeographed form.

More than 40 nationally known experts contributed papers. Subjects covered include preventive maintenance, inspection procedures and frequencies, records and reports, training personnel for maintenance, organization and management for maintenance, costs, incentive payment of maintenance workers, planning and scheduling maintenance operations, applied lubrication, housekeeping, painting and decorating and sanitation.

Included are questions and answers submitted after each of the 12 sessions. These discussions cover heating and power plant equipment, problems of the small plant, selection and maintenance of lighting equipment, maintenance in chemical plants, food processing plants and other industrial plants.

Techniques of Plant Maintenance — 1951. Cloth bound, 8½ x 11 inches, 223 pages. Available from Clapp & Poliak, Inc., 341 Madison Ave., New York 17, N. Y. Price, $6.

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MALLEABLE-IRON SCREWED FITTINGS.—A standard on Malleable-Iron Screwed Fittings, 300 lb class, has been issued by The American Society of Mechanical Engineers. Besides this association, the sponsoring group includes Heating, Piping, and Air Conditioning Contractors National Association, and the Manufacturers Standardization Society of the Valve and Fittings Industry. The first edition of this standard was published in 1932. This 12-page ASA standard may be obtained from the ASME, 29 W. 39th St., New York 18, N. Y.

HYDROGENATION OF COAL AT HIGH TEMPERATURES—The high heating value of natural gas compared to other fuels makes it most desirable for industrial and domestic use. Manufactured gases are now being developed to economically replace the natural gases. This report presents data obtained as the result of an investigation at the hydrogenation of Indiana fourth seam coal in a batch autoclave, over the temperature range of 1,200 to 1,450F and at pressures up to 6,000 lb per square inch. Thermodynamic considerations dictate the use of high pressures to improve the equilibrium yield in the temperature range studied. This is Report No. 3 of Series No. 111. Engineering Experiment Station, Purdue University, Lafayette, Indiana.

STEEL BUTT-WELDING FITTINGS — Sponsored by the Heating, Piping and Air Conditioning Contractors National Association, Manufacturers Standardization Society of the Valve and Fittings Industry, and the American Society of Mechanical Engineers, Bulletin ASA B16.9-1951 has been issued on steel butt-welding fittings. It covers over-all dimensions, tolerances, and markings for wrought and cast carbon and alloy steel welding fittings. American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y. Price, 75 cents.

DEGREE-DAYS FOR JUNE, 1951

(A) Airport readings; (C) City office readings; (O) Readings at a point on outskirts of city.

HEATING AND VENTILATING's 23rd Year of Publication of Monthly Degree-Day Data

City	June			Cumulative, September 1 to June 30			Heating Season[1]
	1951	1950	Normal	1950-51	1949-50	Normal	Normal
Abilene, Texas (A)	5	1	0	2496	2208	2061	2061
Albany, New York (A)	60	71	0	6491	6902	6580	6580
Albuquerque, New Mexico (A)	5	0	0	3771	3852	4298	4298
Alpena, Michigan (C)	136	132	138	7734	7987	7265	8299*
Anaconda, Montana (C)	399	337	251	8519	8685	8261	8357**
Asheville, North Carolina (C)	2	12	0	4218	3580	4232	4232
Atlanta, Georgia (C)	0	0	0	2987	2453	2890	2890
Atlantic City, New Jersey (C)	29	23	0	4445	4470	5176	5176
Augusta, Georgia (A)	0	0	0	2637	1853	2461	2161
Baker, Oregon (C)	227	237	213	6669	7328	7163	7163
Baltimore, Maryland (C)	10	0	0	4144	3921	4533	4533
Billings, Montana (A)	246	165	60	7624	7847	7119	7119
Binghamton, New York (C)	69	90	0	6229	6369	6808	6808
Birmingham, Alabama (A)	0	1	0	2906	2240	2352	2352
Bismarck, North Dakota (A)	189	104	45	9954	10161	9192	9192
Block Island, Rhode Island (A)	92	90	99	5136	5397	5788	5788
Boise, Idaho (A)	106	114	0	6381	6118	5552	5552
Boston, Massachusetts (A)	63	12	0	5132	5558	6045	6045
Bozeman, Montana (C)	389	265	230	8684	8285	8425	8521**
Buffalo, New York (A)	42	77	12	6390	6520	6822	6822
Burlington, Iowa (A)	34	40	(a)	6124	6658	(a)	(a)
Burlington, Vermont (A)	80	61	3	7200	7543	7514	7514
Butte, Montana (C)	424	308	236	8948	8910	8162	8235**
Cairo, Illinois (C)	2	0	0	4113	3497	3909	3909
Canton, New York (C)	(a)	90	0	(a)	7853	8020	8020
Charleston, South Carolina (C)	0	0	0	2031	1394	1769	1769
Charlotte, North Carolina (A)	0	0	0	3139	2696	3120	3120
Chattanooga, Tennesee (A)	0	0	0	3423	2872	3118	3118
Cheyenne, Wyoming (A)	308	158	126	7442	7271	7466	7466
Chicago, Illinois (C)	70	44	59	(a)	5924	6077	6077
Cincinnati, Ohio (C)	0	5	0	4757	4155	4684	4684
Cleveland, Ohio (A)	26	41	0	6000	5795	6155	6155
Columbia, Missouri (A)	14	16	0	5283	4704	4922	4922
Columbia, South Carolina (C)	0	0	0	2544	2057	2364	2364
Columbus, Ohio (C)	7	19	0	5459	4980	5398	5398
Concord, New Hampshire (A)	108	76	54	6786	7369	7353	7353
Concordia, Kansas (C)	44	16	0	5524	5358	5315	5315
Dallas, Texas (A)	0	1	0	2298	2079	2256	2256
Davenport, Iowa (C)	35	28	0	6622	6151	6289	6289
Dayton, Ohio (A)	10	37	0	9976	5433	5264	5264
Deer Lodge, Montana (C)	389	292	235	8558	8547	8582	8672**
Denver, Colorado (C)	164	62	0	5962	5328	5874	5874
Des Moines, Iowa (A)	54	33	0	6944	6486	6384	6384
Detroit, Michigan (A)	32	46	0	6307	6317	6490	6490
Devils Lake, North Dakota (C)	204	154	96	10552	11059	9970	9970
Dodge City, Kansas (A)	50	12	0	5132	4865	5035	5035
Dubuque, Iowa (C)	79	35	0	7436	6830	6790	6790
Duluth, Minnesota (C)	263	232	216	9822	9960	9493	9483
Eastport, Maine (C)	265	272	300	7083	7671	8241	8520**
Elkins, West Virginia (A)	38	71	0	5848	5448	5697	5697
El Paso, Texas (A)	0	0	0	2373	2143	2428	2428
Ely, Nevada (A)	0	255	(a)	0	7558	(a)	(a)
Erie, Pennsylvania (C)	36	44	0	5905	5823	6273	6273
Escanaba, Michigan (C)	167	175	138	8411	8719	8746	8771
Evansville, Indiana (A)	5	5	0	4974	4247	4980	4244
Fort Smith, Arkansas (A)	0	1	0	3478	3109	3147	3147
Fort Wayne, Indiana (A)	26	55	0	6445	6102	5925	5925
Fort Worth, Texas (A)	0	0	0	2328	2113	2148	2148
Fresno, California (A)	2	0	0	2256	2690	2334	2334
Galveston, Texas (C)	0	0	0	1115	653	1016	1016
Grand Junction, Colorado (A)	49	32	0	5310	5651	5548	5548
Grand Rapids, Michigan (A)	58	81	0	6770	6509	6535	6535
Green Bay, Wisconsin (C)	124	97	0	8481	8413	7825	7825
Greensboro, North Carolina (A)	1	0	0	3941	3470	3529	3529
Greenville, South Carolina (A)	0	0	0	3264	2849	3380	3380
Harrisburg, Pennsylvania (A)	28	8	0	5261	5122	5375	5375
Hartford, Connecticut (A)	54	48	0	5556	6001	6036	6036
Hatteras, North Carolina (C)	1	0	0	2532	1891	2571	2571
Havre, Montana (C)	251	164	144	8985	9419	8700	8700
Helena, Montana (A)	336	250	171	8657	8739	7834	7894**
Houston, Texas (C)	0	0	0	1209	852	1157	1157
Huron, South Dakota (A)	130	61	0	8434	8625	8004	8004
Indianapolis, Indiana (A)	13	29	0	5948	5305	5298	5298
Jackson, Mississippi (A)	0	0	(a)	2300	1729	(a)	(a)
Kansas City, Missouri (A)	20	9	0	5139	4742	4956	4956
Knoxville, Tennessee (A)	0	1	0	3751	3129	3670	3670
La Crosse, Wisconsin (A)	53	36	0	8132	8082	7322	7322
Lander, Wyoming (A)	303	178	135	7724	7898	7947	7947

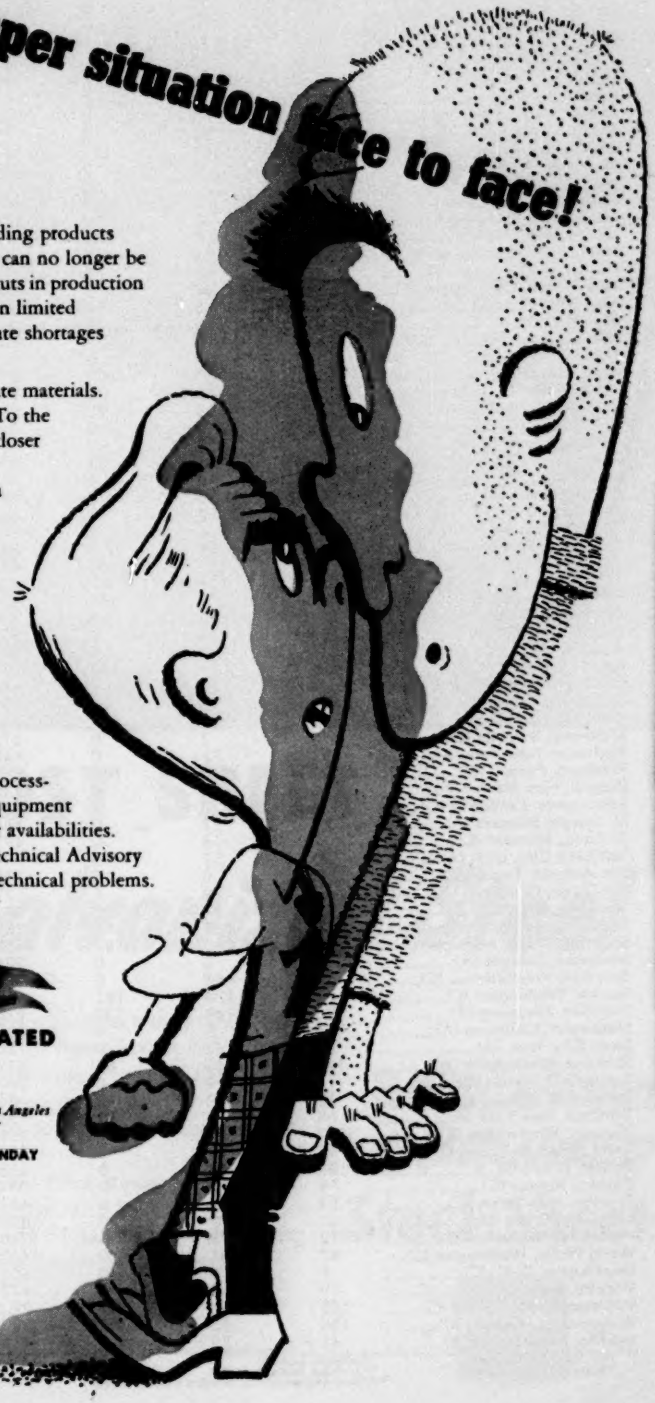
(a) Data not available.

[1]Figures in this column are normal totals for a complete heating season, September to June, inclusive.

Figures in this table, with seven exceptions, based on local weather bureau reports. Exceptions are Utica and Lewiston, figures for which are furnished through the courtesy of Coke Sales Department, Central New York Power Corp., Utica, N. Y., and Norman R. Ross, Bursar, Bates College, Lewiston, Me., respectively; Anaconda, Bozeman, Butte, Deer Lodge and Livingston, Mont., through the courtesy of the Montana Power Company.

[Table concluded on page 118]

let's meet the copper situation face to face!



● In the months ahead there will be some building products formerly made of copper and copper alloys that can no longer be made of these materials. Others, due to required cuts in production and D.O. rated orders getting first call, will be in limited supply. Further complications arise from the acute shortages of raw materials.

In some cases you will be forced to use substitute materials. But that doesn't mean we must part company. To the contrary, the present situation should bring us closer together. Because you're going to have more problems than ever, we may be able to help you through Revere's Technical Advisory Service.

This Service is backed by a wealth of knowledge accumulated over a century and a half of working with metals. Why not put that knowledge to work for you? Revere would like to collaborate with you regarding the usage, to their best advantage, of the products you *can* get.

And don't forget, while supplies are limited, you can still use Revere Copper Water Tube in domestic hot and cold water lines, industrial processing lines, underground service lines, and gas equipment piping. Check with your Revere Distributor for availabilities. He will also put you in touch with Revere's Technical Advisory Service in the event you wish to discuss your technical problems.

REVERE 150 YEARS

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SEE "MEET THE PRESS" ON NBC TELEVISION EVERY SUNDAY

Degree-Days for June, 1951 (Concluded)

(A) Airport readings; (C) City office readings; (O) Readings at a point on outskirts of city.

HEATING AND VENTILATING's 23rd Year of Publication of Monthly Degree-Day Data

City	June			Cumulative, September 1 to June 30			Heating Season[1]
	1951	1950	Normal	1950-51	1949-50	Normal	Normal
Lansing, Michigan (A)	50	70	0	6914	6910	7048	7048
Lewiston, Maine (O)	122	(a)	45	6792	(a)	7707	7707
Lincoln, Nebraska (C)	53	26	0	6183	6038	5999	5999
Little Rock, Arkansas (A)	0	0	0	3186	2711	2811	2811
Livingston, Montana (C)	322	233	142	7560	7460	7185	7245**
Los Angeles, California (C)	7	17	0	1131	1487	1504	1504
Louisville, Kentucky (A)	0	3	0	4777	4023	4180	4180
Lynchburg, Virginia (A)	1	0	0	4303	3834	3980	3980
Macon, Georgia (A)	0	0	0	2322	1788	2201	2201
Madison, Wisconsin (C)	56	53	0	7595	7334	7429	7429
Marquette, Michigan (C)	259	187	186	8462	8712	8650	8693*
Memphis, Tennessee (A)	0	0	0	3384	2838	2950	2950
Meridian, Mississippi (A)	0	0	0	2449	1877	2160	2160
Milwaukee, Wisconsin (A)	115	64	39	7485	7155	7245	7245
Minneapolis, Minnesota (A)	78	62	0	8484	8410	7850	7850
Montgomery, Alabama (A)	0	0	0	2295	1544	1884	1884
Nantucket, Massachusetts (A)	140	113	123	5387	5744	5957	5957
Nashville, Tennessee (A)	0	1	0	3987	3311	3507	3507
New Haven, Connecticut (A)	53	67	0	5387	5763	5895	5895
New Orleans, Louisiana (C)	0	0	0	1226	775	1024	1024
New York, N. Y. (C)	29	26	30	4620	4669	5274	5274***
Nome, Alaska† (A)	765	970	973	15580	11928	13058	14580**
Norfolk, Virginia (C)	2	0	0	3146	2736	3350	3350
North Head, Washington (C)	301	252	309	4912	5212	5002	5452**
North Platte, Nebraska (A)	124	46	0	6562	6682	6366	6366
Oakland, California (A)	132	158	93	2499	3176	2963	3143**
Oklahoma City, Oklahoma (C)	8	2	0	3570	3321	3613	3613
Omaha, Nebraska (A)	57	23	0	6574	6311	6131	6131
Oswego, New York (C)	78	86	63	6547	6694	7088	7088
Parkersburg, W. Virginia (C)	3	16	0	4878	4445	4775	4775
Peoria, Illinois (A)	24	36	0	6435	5949	6109	6109
Philadelphia, Pennsylvania (C)	21	12	17	4387	4360	4737	4737***
Phoenix, Arizona (C)	0	0	0	1019	1124	1405	1405
Pittsburgh, Pennslyvania (C)	2	16	0	5254	4834	5235	5235
Pocatello, Idaho (A)	174	153	60	6531	7028	6655	6655
Portland, Maine (A)	171	111	81	6925	7470	7218	7218
Portland, Oregon (C)	48	102	90	3967	4653	4469	4469
Providence, Rhode Island (C)	54	26	0	4985	5470	6015	6015
Pueblo, Colorado (A)	81	34	0	5539	5057	5514	5514
Raleigh, North Carolina (C)	0	0	0	3202	2747	3234	3234
Rapid City, South Dakota (A)	220	107	30	7549	7938	7118	7118
Reading, Pennsylvania (C)	24	14	0	4849	4858	5358	5389
Red Bluff, California (A)	0	13	(a)	2504	2833	(a)	(a)
Reno, Nevada (A)	104	170	90	6342	5960	5892	5892
Richmond, Virginia (C)	0	2	0	3751	3315	3695	3695
Rochester, New York (A)	53	72	0	6474	6671	6732	6732
Roseburg, Oregon (C)	(a)	(a)	114	(a)	(a)	4428	4428
Roswell, New Mexico (A)	11	1	0	3350	3124	3484	3484
Sacramento, California (C)	9	22	0	2314	2625	2653	2653
St. Joseph, Missouri (A)	21	12	0	5690	5383	5161	5161
St. Louis, Missouri (C)	7	4	0	4978	4263	4585	4585
Salt Lake City, Utah (A)	(a)	57	0	(a)	5888	5555	5555
San Antonio, Texas (A)	0	0	0	1564	1152	1202	1202
San Diego, California (A)	4	29	6	1226	1281	1645	1645
Sandusky, Ohio (C)	15	24	0	5863	5514	6208	6208
San Francisco, California (C)	257	238	195	2688	3028	2876	3264**
Sault Ste. Marie, Michigan (A)	238	280	189	8774	9463	9139	9285**
Savannah, Georgia (A)	0	0	0	2041	1333	1490	1490
Scranton, Pennsylvania (C)	49	58	0	5734	5845	6129	6129
Seattle, Washington (C)	82	120	162	4259	4916	4857	4934**
Sheridan, Wyoming (A)	273	149	120	7702	8136	8008	8008
Shreveport, Louisiana (A)	0	0	0	2258	1807	1938	1938
Sioux City, Iowa (A)	68	47	0	7301	7323	6898	6898
Spokane, Washington (A)	129	160	81	6497	7462	6355	6355
Springfield, Illinois (C)	16	9	0	5679	5035	5373	5373
Springfield, Missouri (A)	15	19	0	4869	4457	4428	4428
Syracuse, New York (A)	65	72	12	6580	6625	6893	6893
Tacoma, Washington (C)	122	152	183	4699	5275	5066	5181**
Terre Haute, Indiana (A)	15	23	0	5827	5112	4872	4872
Toledo, Ohio (A)	25	40	0	6382	6154	6077	6077
Topeka, Kansas (C)	19	12	0	5149	4887	4969	4969
Trenton, New Jersey (C)	29	20	0	4821	4853	4933	4933
Utica, New York (O)	61	99	0	6399	6940	6796	6796
Valentine, Nebraska (C)	172	79	0	7409	7642	7039	7039
Walla Walla, Washington (C)	47	81	0	4620	5501	4808	4808
Washington, D. C. (C)	9	0	0	4076	3808	4626	4626
Wichita, Kansas (A)	19	12	0	4771	4521	4673	4673
Williston, North Dakota (C)	185	151	54	9907	10270	9323	9323
Winnemucca, Nevada (C)	136	155	117	5838	6472	6391	6427**
Yakima, Washington (A)	46	79	0	4464	6536	5599	5599

(a) Data not available.
†Nome data are for May

*Includes August.
**Includes July and August.
***New 48-year normal covering 1898 to 1946.

[1]Figures in this column are normal totals for a complete heating season, September to June, inclusive.

The LOW-COST SHEET *is Galvanized Steel*

When you compare galvanized sheet steel with other metals on the basis of equal strength, you will find a substantial difference in cost. Other metals must be used in relatively thick and expensive gages to equal the strength and stiffness of steel in comparatively light gages.

Or, if you compare galvanized steel with other metals in equal weights —you will see that steel is again priced lower.

Bethlehem Galvanized Sheets are made from strong, durable steel, either plain or copper-bearing, and are coated with Prime Western zinc for good corrosion-resistance. They are easy to handle without kinking, they have excellent workability, they give a finished look to any job.

Bethlehem GALVANIZED Steel Sheets

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation

***Export Distributor:* Bethlehem Steel Export Corporation**

NEWS OF THE MONTH

SURFACE TEMPERATURES

of window glass offered in warm air data sheet showing limit of indoor humidity.

A new publication under the title *Questions and Answers*, by the National Warm Air Heating and Air Conditioning Association, offers a table of inside window surface temperatures at various outside air temperatures. The table also shows the relative humidity indoors at which condensation may be expected to form on glass in windows of various types.

Values of inside surface temperatures were calculated from the formula,

$$t_s = 70 - \frac{U}{1.5}(70 - t_o)$$

where t_s = temperature of inner surface of glass, F
70 = room air temperature, F
U = heat transmission coefficient of window, Btu per (sq ft) (hr) (F)
1.5 = surface coefficient of glass under still air conditions, Btu per (sq ft) (hr) (F)
t_o = outside air temperature, F

• **EXAMPLE.**—Use of the table is illustrated by an example of a homeowner living in an area where the outdoor temperature may drop to zero or below. If the homeowner wishes to maintain a relative humidity of 30% in his home, the table shows that the ordinary single pane window with a heat transmission coefficient of 1.13 would not be suitable, since condensation would occur at 12% humidity. With the addition of an ordinary storm sash, he could maintain a relative humidity of 27%, but to maintain 30% as a minimum it would be necessary to go on down the table to the type of window that has either two glass panes hermetically sealed in the frame or a very tightly fitted storm sash.

RESEARCH GRANTS

by ASRE aid 18 refrigeration research projects at several U. S. colleges.

The American Society of Refrigerating Engineers through its research committee under the chairmanship of C. M. Ashley, Carrier Corp., has recently authorized grants to a number of colleges for the

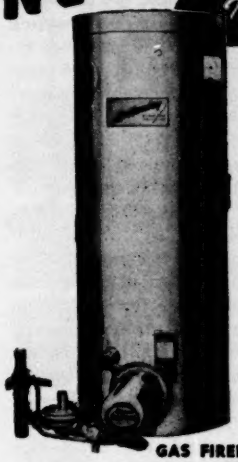
TABLE 1—INSIDE WINDOW SURFACE TEMPERATURES AND HUMIDITY LIMITS OF 70F AIR.

U Value of Glass	Type of Window: No. Glass Panes	No. Air Spaces	Type of Air Space Between Panes	Air Space Width, Inches	Outside Air Temperature, Degrees F: —30	—20	—10	0	10	20	30	40	50	60
					In each pair of values below, the upper one is the temperature in degrees F of the inner surface of the glass and the lower one is the relative humidity of 70-deg room air above which condensation may be expected to form on the glass.									
1.13	1	None	....	....	—6 2%	2 5%	9 8%	17 12%	25 18%	32 24%	40 32%	47 43%	55 58%	62 75%
0.75	2	1	Note 1	1½	20 14%	25 18%	30 22%	35 27%	40 32%	45 40%	50 48%	55 58%	60 70%	65 84%
0.63	2	1	Sealed Note 3	¼	28 20%	32 24%	36 28%	40 32%	45 40%	49 47%	53 54%	57 63%	62 75%	66 87%
0.57	2	1	Sealed Note 3	½	32 24%	36 28%	39 30%	43 37%	47 43%	51 50%	55 58%	59 68%	62 75%	66 87%
0.45	2	1	Note 2	1½	40 32%	43 37%	46 41%	49 47%	52 52%	55 58%	58 65%	61 72%	64 81%	67 90%
0.43	3	2	Sealed Note 3	¼	42 36%	44 39%	47 43%	50 48%	53 54%	56 60%	59 68%	61 72%	64 81%	67 90%
0.38	3	2	Sealed Note 3	½	44 39%	47 43%	50 48%	52 52%	55 58%	57 63%	60 70%	62 75%	65 84%	67 90%

Note 1. Window with usual storm sash.
Note 2. Windows with very tightly fitted storm sash and no ventilator openings in sash.
Note 3. Windows with two or three glass panes hermetically sealed in the sash to prevent air leakage into spaces between panes.

NEW! Mt Hawley "BUDGETEER" BOILER BURNER

Ideal for Today's "Small Home" Market



GAS FIRED

Here's a high quality, space-saving, low cost boiler especially designed to meet EVERY requirement of the ever expanding "small home" market.

Its efficient dimensional design lends itself excellently to either basement or utility room installations.

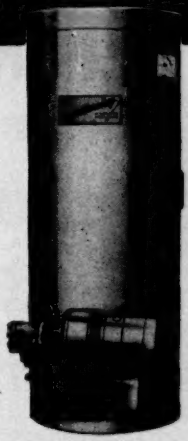
The outstanding new Mt. Hawley "Budgeteer", featuring heavy gauge, slanting tube construction, can be quickly and easily converted from oil to gas or vice versa.

It is available with domestic water coil and has a capacity of 510 ft. of hot water radiation.

Priced right, it is shipped completely insulated and jacketed for quick, easy installation.

Cash in — now — by stocking the new Mt. Hawley "Budgeteer" — the boiler especially designed for the "small home" market!

Complete details sent on request.



OIL FIRED

SIMPLE INTERCHANGEABILITY
GAS TO OIL OIL TO GAS

In the matter of minutes, the "Budgeteer" can be changed on the job from oil to gas or vice versa. This flexibility of firing equipment is a feature of interest to architects, engineers, builders and tradesmen alike, as it permits the owner to have the fuel of his choice NOW OR LATER.

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PER UNIT OF ACTUAL COOLING CAPACITY

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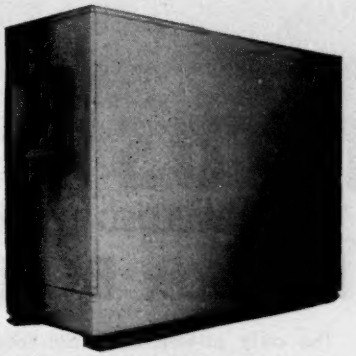
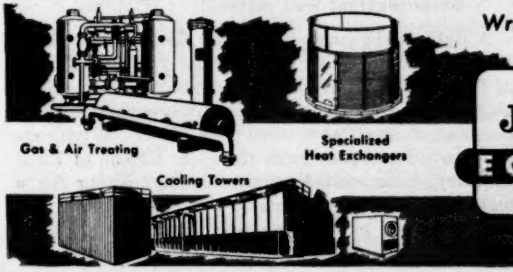
COTOPACK* COOLING TOWERS



Here is quality never before offered in a low cost tower! Just look at these advantages... Centrifugal blower is corrosion-proof coated and dynamically balanced for quiet operation, high capacity with low horsepower, longer life... All joints are welded water-tight... Gravity-type distribution is self-cleaning ... Motor totally enclosed with belt tension adjustment. Six to twenty ton capacity. Shipped completely assembled. Easily installed.

Write for Bulletin No. 5.6.082A Today!

*Registered Trade Name



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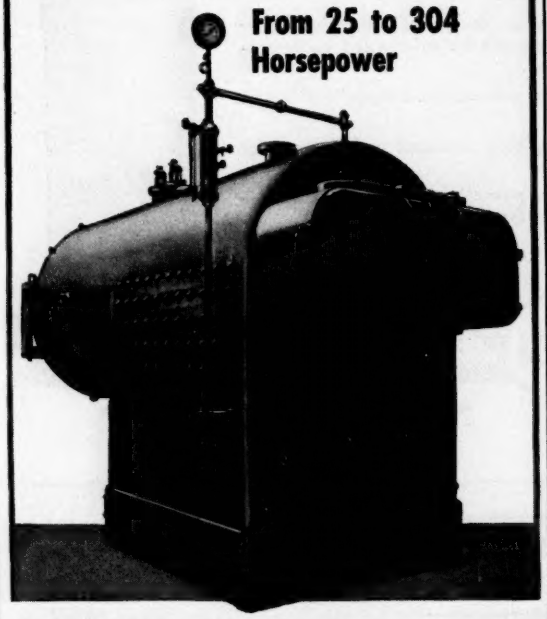

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ALL-WELDED WP-WPO

Firebox BOILERS

The *only* all-welded, return tube, firebox type high pressure boiler—providing leak-proof, troubleproof performance on continuous schedules for hospitals, institutions and industries. The Titusville Type WP-WPO Firebox Boiler is precision die formed and welded —built to ASME code with a 5-plus factor of safety—Standardized ratings, with large reserve capacity—gives excellent results with oil, gas or coal firing. Write for detailed, descriptive brochure.

THE TITUSVILLE IRON WORKS COMPANY

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furtherance of research on subjects pertaining to refrigeration.

These grants were made under the policy whereby the ASRE sponsors wholly or in part a number of research projects each year. Although the research committee recommends the subject, and progress reports are submitted semi-annually before each convention, the colleges are given a completely free hand in regard to the manner in which they work.

At the present time, there is a total of eighteen active research projects being conducted under the sponsorship of ASRE. Among those colleges participating are Oklahoma A & M, Case Institute of Technology, and St. Louis University.

• **DESICCANTS.**—At Oklahoma A & M, under the direction of Dr. L. H. Bartlett, the problem of refrigerant desiccants will be studied to determine the equilibrium distribution of water between liquid refrigerants and desiccants. This investigation was initiated at the joint request of the standards committee and the research committee as a result of a controversial paper on desiccants presented at an ASRE convention a few years ago. The controversy revolved about the nature of desiccants, their functions, and the nature of the mechanical or chemical processes involved in the drying operation. The project was started at Louisiana State University under the direction of Dr. Bartlett with some excellent results to date, but it was felt preferable to transfer the work when he moved to his new position at Oklahoma A & M.

• **EVAPORATORS.**—At Case Institute the subject is heat transfer coefficients for boiling in a horizontal tube evaporator. This is a continuation of two previous projects which were supported in part by ASRE, and it is hoped by further experimentation to determine a method for designing direct expansion evaporators based on fundamental design data. Professor W. L. Bryan of Case Institute hopes that continued effort will lead to a quantitative and qualitative understanding of the direct expansion evaporator.

St. Louis University, under Father B. J. Luyet, will study the preservation of frozen plant tissues in the living state, and North Carolina State College under Professor K. O. Beatty will study sensible vs. latent heat transfer during cooling of humid air.

In addition, the grant to the University of Kentucky was increased so that they could continue work on the deterioration of meat under various storage conditions.

AIR-GRAVEL CONCRETE

developed for farms, proves good insulator and water-resistant wall material.

A lightweight concrete recently developed by R. C. Valore, Jr., and W. C. Green of the National Bureau of Standards substitutes air bubbles for sand. Suitable for the construction of monolithic walls and other elements of small structures, this air-gravel concrete grew out of a request from the U. S. Bureau of Plant Industry, Soils, and Agricultural Engineering for a material particularly adaptable to farm buildings. The many tiny air bubbles enclosed within the material not only replace the sand used in ordinary dense con-

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is BEST FOR DUCT INSULATION

1 High thermal and acoustical insulating properties... K factor of .27 BTU and sound absorption approximately 61%. Integral, woven asbestos membrane.

2 Easy to handle, easy to install correctly, can't be crushed or cracked, springs back to original thickness if compressed. Supplied with special glue and tape, no "fasteners" needed.

3 Constant insulating values. Can't "powder", shift or sift; no thin spots, even at corners. No deterioration of any kind, no change of any kind.

4 Perfect adhesion, flexible, conforms to uneven surfaces. Can be installed in the shop and still withstand all necessary handling. Specifically engineered for duct application ONLY!

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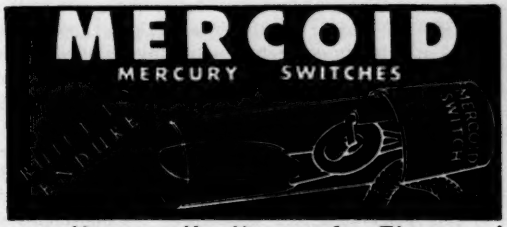
MERCOID

MERCURY SWITCHES



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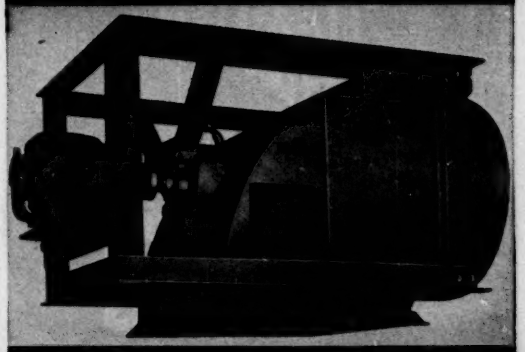
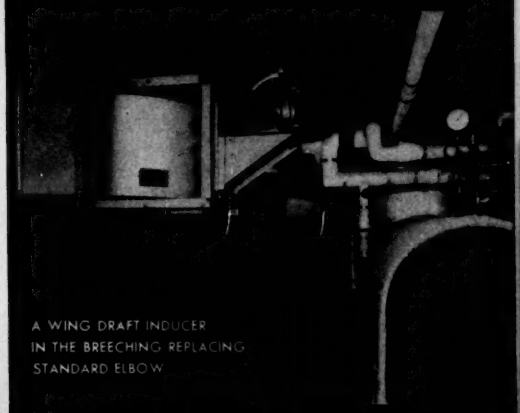
THIS IS THE WING DRAFT INDUCER



THIS IS A TYPICAL INSTALLATION



A WING DRAFT INDUCER IN THE BREECHING REPLACING STANDARD ELBOW

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2. Cut fuel costs. Give higher CO_2's. Less excess air.
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crete, but also make the product lighter in weight, a better insulator against heat or cold, and more resistant to water penetration.

Concrete normally contains a coarse aggregate such as gravel or crushed stone, held together by a binder of mortar consisting of sand and cement-water paste. In the air-gravel concrete the fine aggregate or sand is replaced by air bubbles, which act as a lubricant and produce a very workable mixture. High-air-content concrete is prepared in conventional mixing equipment in the normal way, except that an industrial aerating agent or a detergent is added to the mix to cause it to foam by entraining finely-divided air cells in the cement-water paste. Entrained air may constitute up to 45% of the volume of the concrete prepared at the Bureau, and "pea gravel" forms the dense aggregate.

• **WORKABILITY.**—One of the important functions of fine aggregate sand in conventional concrete is to produce workability, which facilitates placing in forms and assures homogeneity in structural members. Results of an investigation at NBS indicate that the replacement of conventional fine aggregate by entrained air likewise produces workable mixtures having relatively low water-cement ratios. The mixtures studied consisted of a high-early-strength portland cement, siliceous pea gravel (No. 4 to ⅜-inch sieve fraction), water, and an air-entraining agent. Two different air-entraining agents (foam stabilizers) were used: a proprietary neutralized resin; and a proprietary sodium lauryl sulfate-type detergent. The falling action of the gravel particles during mixing in an ordinary rotating tilt-drum mixer produced the entrainment of air in the cement-water paste, and the air-entraining agent rendered the foamed paste stable.

• **STRENGTH.**—Air contents as high as 45% were found possible in concretes containing no sand, while there appeared to be an upper limit of about 30% in the air content of experimental mixtures containing both sand and gravel. However, the amount of entrained air, upon which the density depends, was limited critically by the minimum compressive strength requirement of 500 lb per sq inch. The lowest cement content permitting the attainment of the required strength in an air-gravel concrete was about 3¼ bags of cement per cubic yard of concrete. In this lean mix (mix A) it was necessary to maintain an air content of about 25% to provide the necessary workability and strength. A second mix (mix C), containing about 5.6 bags of cement per cubic yard of concrete, provided the required strength for air contents as high as 29%.

The compressive strength was sensitive to variations in air content; an increase of 1% in air content was generally accompanied by a decrease of about 100 lb per sq inch in compressive strength for both mixes. The indicated density of concretes having a compressive strength at 28 days of 500 lb per sq inch was about 113 lb per cu ft for mix A, and 105 and 109 lb per cu ft respectively for mix C concretes made with the resin and detergent air-entraining agents, as compared with 140 to 145 lb per cu ft for conventional (nonaerated) sand-gravel concretes. While the compressive strengths were only one-fourth to one-fifth the values obtained for nonaerated concretes, the moisture properties and thermal conductivity of the air-

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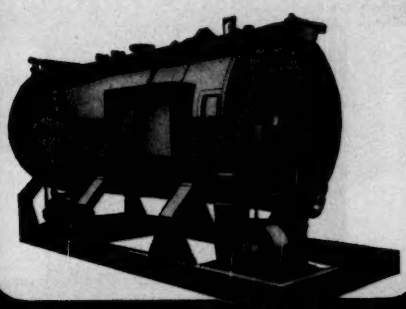

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gravel concretes compared favorably with the values obtained for the denser concretes.

• **WATER RESISTANCE.**—The mean water absorption of the lightweight concretes upon soaking for 24 hours at room temperature was about 9% (by volume) for all mixes, compared with 11 to 15% for conventional concretes of similar materials and cement contents. Saturation coefficients, calculated as the ratio of the 24-hour room temperature absorption, to the 5-hour boiling absorption, ranged from 0.22 to 0.36, or about one-third the magnitude of values previously reported for nonaerated sand-gravel concretes. The saturation coefficient purports to represent the ratio of the pore volume easily filled by water per total pore volume. The drying shrinkage of the air-gravel concretes did not differ significantly from values obtained for nonaerated sand-gravel concretes, ranging from 0.04 to 0.07% for 2- by 12-inch prisms after 180 days drying.

• **FREEZING.**—Of 13 specimens of mix A and mix C concretes subjected to 100 cycles of laboratory freezing (0F air) and thawing (70F water), only one specimen (mix C) failed at 40 cycles. Two specimens of nonaerated sand-gravel concrete failed at 60 cycles.

• **CONDUCTIVITY.**—The thermal conductivity of these concretes, as determined in the NBS guarded hot-plate test, ranged from about 5 to 6 Btu (inch) per (hr) (sq ft) (F); a value obtained in tests of a nonaerated sand-gravel concrete was 9. A value often cited for conventional concretes is 12, but values ranging from 7 to 16 have been reported by various observers.

The air-gravel concretes developed at the National Bureau of Standards are considered experimental at the present time. The advantages in reduced density and thermal conductivity are appreciable but are gained only at a great sacrifice in strength.

GENERATOR HOOK-UP SUPPLIES LARGE AMOUNTS OF HOT WATER

(Continued from page 76)

tube unit, which eliminates the need for high welding costs on the job and the built-in air cushion, make the unit extremely compact.

Brooklyn Union has been particularly interested in the subject of immersion coil water heating because of the basic advantages a water heater operating on the indirect principle has as contrasted to the direct type heaters usually encountered. Use of the indirect principle, with its unchanging boiler water, eliminates the possibility of condensation and carbonization of the coils commonly used in gas-fired water heaters.

While the usefulness of the generator hook-up described has proven itself in the relatively few applications with which the company has had experience, the extent to which this hook-up will be employed remains to be seen. Brooklyn Union experience has been confined to the apartment house and office building fields but it appears likely that it could be used in many other types of commercial and industrial buildings such as hospitals, institutions of various types, and factories, with important savings to the owners.

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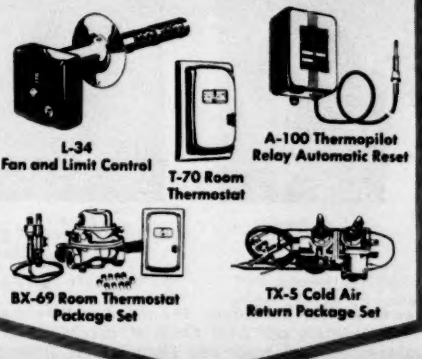
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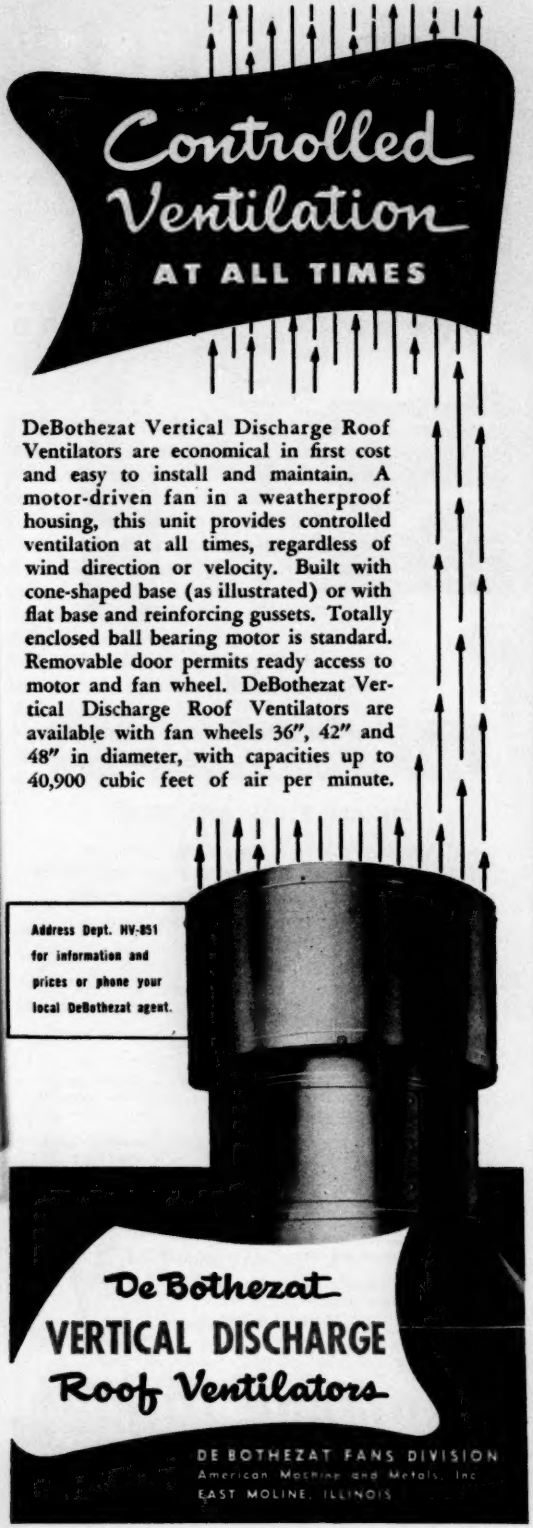
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Getting Personal

Robert H. Page (coauthor, *Analysis of Data on Flow of Steam in Pipes*, page 85) is assistant in mechanical engineering, Mechanical Engineering Department, University of Illinois. Born in Philadelphia, Pa., Nov. 5, 1927, he attended Virginia Military Institute, University of Pennsylvania, Ohio University, and University of Illinois, received the B.S.M.E. degree from Ohio University and the M.S.M.E. degree from the University of Illinois. He served in the U. S. Army for 28 months in the United States and Hawaii. He is married and has one child. He is a member of Alpha Phi Omega, Pi Epsilon Mu, and Pi Tau Sigma, associate member of Sigma Xi, and a student member of ASHVE.

S. Konzo (coauthor, *Analysis of Data on Flow of Steam in Pipes*, page 85) is a native of Tacoma, Wash. Following almost 20 years of outstanding work in research in warm air heating and air conditioning, he has been, since 1947, professor of mechanical engineering in the graduate school of the University of Illinois. A more detailed biographical sketch appeared in the June, 1949, issue of H&V in connection with a previous article, *Air Requirements for Summer Cooling as Affected by Heat Gain in Ducts.*

Frank H. Bridgers (co-author, *The Effect of Ethylene Glycol on Pipe Friction and Heat Transfer*, page 61, July issue) has recently opened a consulting engineering office in Albuquerque, N. M. He was formerly with the office of Charles S. Leopold, Consulting Engineer of Philadelphia. Before opening his office in Albuquerque, he had spent almost two years at the atomic city of Los Alamos, N. M., working on projects with which Mr. Leopold is connected. He was formerly on the teaching staff at Purdue University where he earned a M.S. of M.E. degree. During World War II he served with the U. S. Army Corps of Engineers in China.

F. H. Bridgers

J. Bricker

James Bricker (co-author, *The Effect of Ethylene Glycol on Pipe Friction and Heat Transfer*, page 61, July issue) graduated in 1933 from The Pennsylvania State College with a B.S. in mechanical engineering. He served three years in the U. S. Navy during World War II and was discharged as Lieutenant-Commander. For the past 16 years, except for the time in the service, he has been with Charles S. Leopold, Consulting Engineer, Philadelphia, Pennsylvania. During this period he has been assistant chief engineer in charge of the design of many air-conditioning systems for large department stores, hotels, theaters, etc. At present he is stationed at the A.E.C. operation at Los Ala-

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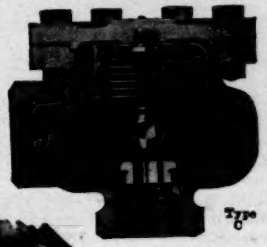

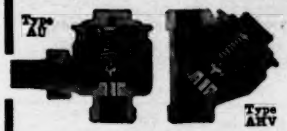

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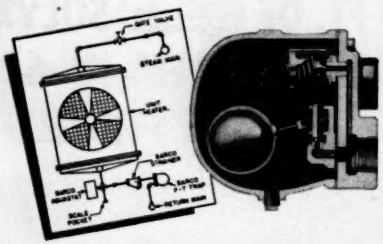

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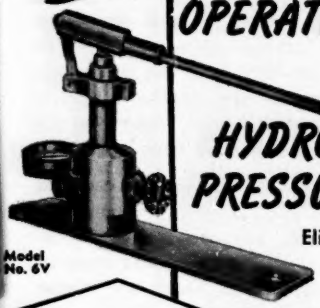

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mos, New Mexico—as Mr. Leopold's resident engineer in charge of the design and installation of the air-conditioning, heating and very special ventilating systems in connection with the various laboratories at Los Alamos.

Wm. A. Xanten (*Large-Scale Odor and Dust Control*, page 65) is Superintendent, Division of Sanitation, Washington, D. C. Mr. Xanten was born in New York City, N. Y., and was educated at Emerson Institute and George Washington University in the District of Columbia. For the past 28 years he has been employed by the District Government in the Division of Sanitation. For many years he has held special assignments as the official in charge of snow removal; chairman of the D. C. Committee on Cleanliness and Sanitation; and chairman of the D. C. Wage Board. For the year 1948-49 he was president of the American Public Works Association and is the author of a number of papers on the general subject of solid waste disposal and street cleaning practices. During World War II he served as a special consultant to the Corps of Engineers on waste collection and disposal practices in the Third Service Command, and directed numerous salvage campaigns for the municipality.

W. A. Xanten

Canadian Degree-Days for May, 1951*

City	May		Cumulative Sept. 1 to May 31	
	1951	Normal	1950-51	Normal
Calgary, Alta.	477	480	10161	9111
Charlottetown, P.E.I.	544	536	7392	8263
Crescent Valley, B. C.	390	403	7566	7731
Edmonton, Alta.	383	428	10758	9797
Fort William, Ont.	403	567	10251	10045
Grande Prairie, Alta.	468	505	11727	10122
Halifax, N. S.	475	493	6340	7395
London, Ont.	271	307	7182	7275
Medicine Hat, Alta.	285	301	9545	8495
Moncton, N. B.	489	474	7681	8568
Montreal, P. Q.	278	325	7747	8413
North Bay, Ont.	356	434	9136	9180
Ottawa, Ont.	281	310	8130	8674
Penticton, B. C.	256	273	6390	6346
Porquis Junction, Ont.	405	558	10558	11144
Prince George, B. C.	484	490	9986	8996
Quebec City, P. Q.	386	428	8259	9276
Regina, Sask.	327	434	11553	10891
St. John, N. B.	484	505	7118	8081
Saskatoon, Sask.	345	397	11750	10478
Toronto, Ont.	229	341	6413	7236
Vancouver, B. C.	324	326	5379	5303
Victoria, B. C.	373	366	5136	4935
Windsor, Ont.	218	251	6568	6705
Winnipeg, Man.	284	397	10690	10841

*These data are supplied through the courtesy of the Meteorological Division, Air Service Branch, Department of Transport, Canada.

COMING EVENTS

Where listed, names or titles of individuals are those from whom further information is available.

REFRIGERATION CONGRESS—Eighth International Congress of Refrigeration, under the auspices of The International Institute of Refrigeration, to be held at the Church House, Westminster,

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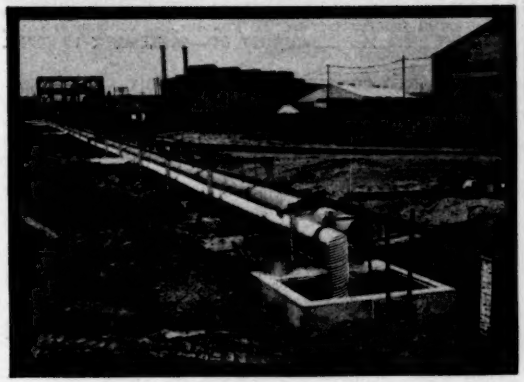

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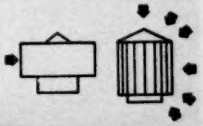

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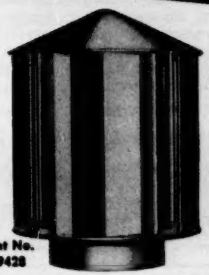

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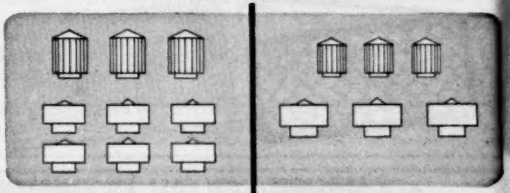

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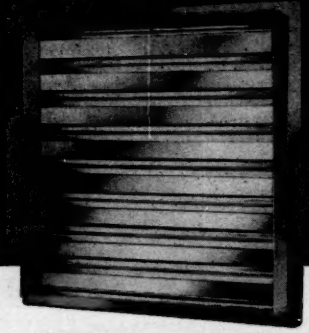

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ENGINEERING EXHIBITION—The Engineering, Marine and Welding Exhibition, sponsored chiefly by The British Engineers' Association, Inc., to be held in London, England. A. W. Berry, director of the Association, 32 Victoria St., London, S. W. 1, England. ..... **AUGUST 30—SEPTEMBER 13, 1951.**

INSTRUMENT CONFERENCE AND EXHIBIT—1951 Instrument conference and national exhibit of the Instrument Society of America, at the Coliseum, Houston, Tex. John McCaffery, assistant executive secretary of the Society, 921 Ridge Ave., Pittsburgh 12, Pa. .....**SEPTEMBER 10-14, 1951.**

ASME MEETING—Fall meeting of the American Society of Mechanical Engineers, at the Radisson Hotel, Minneapolis, Minn. C. E. Davies, secretary of the Society, 29 West 39th St., New York 18, N. Y. .....**SEPTEMBER 25-28, 1951.**

PLUMBING AND HEATING MEETING—Annual meeting of the Plumbing and Heating Industries Bureau, at Palmer House, Chicago, Illinois. Norman J. Radder, secretary of the Bureau, 35 East Wacker Drive, Chicago 1, Illinois. **OCTOBER 11, 1951.**

ELECTRICAL ENGINEERS CONFERENCE—A Technical conference on the application of frictional horsepower motors to refrigeration equipment and pumps, sponsored by the American Institute of Electrical Engineers, at the Dayton Biltmore Hotel, Dayton, Ohio. D. C. Breeding, Frigidaire Division, General Motors Corp., Dayton, Ohio. .....**OCTOBER 11-12, 1951.**

AGA CONVENTION—33rd annual convention of the American Gas Association, at Kiel Auditorium, St. Louis, Mo. Secretary of the Association, 420 Lexington Avenue, New York 17, N. Y. .....**OCTOBER 15-17, 1951.**

PUBLIC HEALTH MEETING—79th annual meeting of the American Public Health Association, at Civic Auditorium, San Francisco, Calif. Willimina Rayne Walsh, associate secretary of the Association, 1790 Broadway, New York 19, N. Y. .....**OCTOBER 29—NOVEMBER 2, 1951.**

REFRIGERATION SHOW—7th All-Industry Refrigeration and Air Conditioning Exposition, at Navy Pier, Chicago, Ill. Show director, REMA 1346 Connecticut Ave., N.W., Washington, D. C. .....**NOVEMBER 5-8, 1951.**

ASME MEETING—Annual meeting of the American Society of Mechanical Engineers, at Chalfonte-Haddon Hall, Atlantic City, N. J. C. E. Davies, secretary of the Society, 29 West 39th St., New York, N. Y. .....**NOVEMBER 25-30, 1951.**

CHEMICAL ENGINEERS MEETING—Annual meeting of the American Institute of Chemical Engineers, at Chalfonte-Haddon Hall, Atlantic City, N. J. Secretary of the Institute, 29 West 39th St., New York 18, N. Y. .....**DECEMBER 2-5, 1951.**

HEATING WHOLESALERS' MEETING—Annual meeting of the National Heating Wholesalers' Association, at the Hotel Statler, Cleveland, Ohio. E. L. Wyman, executive secretary, 609 Commerce Building, Cleveland. .....**DECEMBER 3-4, 1951.**

WARM AIR CONVENTION—38th annual convention of the National Warm Air Heating and Air Conditioning Association, at Hotel Cleveland, Cleveland, Ohio. George Boeddener, 145 Public Square, Cleveland. .....**DECEMBER 5-6, 1951.**

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AUTOMOTIVE ENGINEERS MEETING—Annual meeting of the Society of Automotive Engineers, Inc., at the Hotel Book-Cadillac, Detroit, Mich. John A. C. Warner, secretary of the Society, 29 West 39th St., New York 18, N. Y. ..... **JANUARY 14-18, 1952.**

ELECTRIC ENGINEERING MEETING—Winter general meeting of the American Institute of Electrical Engineers, at the Hotel Statler, New York, N. Y. Secretary of the Institute, 33 West 39th St., New York 18, N. Y.....**JANUARY 21-25, 1952.**

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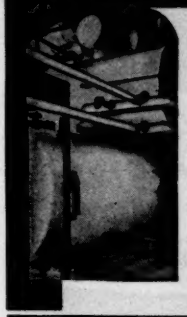

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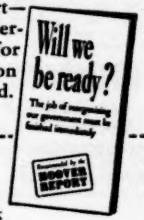

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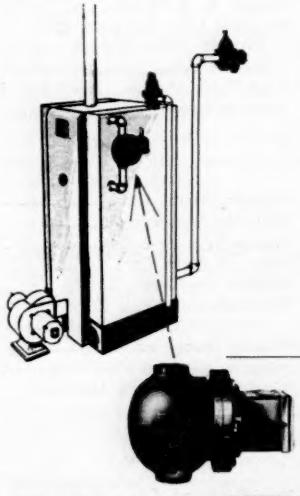

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CONDENSATION ON COLD AIR DUCTS

TABLE 1—TEMPERATURE AT WHICH CONDENSATION OCCURS ON DUCTS.

Surrounding Air Conditions			Straight Duct														Elbows	
			Air Velocity in Duct, Feet per Minute															
			750		1000		1250		1500		1750		2000		2500		500 to 2500	
Dry Bulb, °F	Wet Bulb, °F	Dew Point, °F	Bright Finish	Painted or Black Finish	Bright Finish	Painted or Black Finish	Bright Finish	Painted or Black Finish	Bright Finish	Painted or Black Finish	Bright Finish	Painted or Black Finish	Bright Finish	Painted or Black Finish	Bright Finish	Painted or Black Finish	Bright Finish	Painted or Black Finish
			Dry Bulb Temperature at Which Sweating Occurs, °F.															
95	78.0	71	83.3	86.3	86.4	91.6	87.1	92.6	87.8	93.2	88.2	93.9	88.5	94.4	89.0	95.2	89.6	95.1
	76.0	68	83.0	91.0	86.4	92.5	89.2	93.7	89.6	94.2	89.8	95.4	89.9	96.0	91.2	96.8	90.7	96.0
85	71.5	65	83.0	86.0	83.5	89.3	83.4	89.8	84.0	90.2	84.4	90.8	84.6	91.1	85.1	91.9	86.0	92.6
	71.0	64	80.2	86.1	81.2	87.0	82.3	87.8	83.4	88.5	83.9	89.1	84.1	89.4	84.7	90.1	84.7	90.9
	70.5	63	82.7	84.3	80.8	85.2	80.2	86.1	80.8	86.7	81.4	87.4	81.6	87.7	82.3	88.5	87.5	89.4
	70.0	62	47.0	83.5	83.0	83.3	83.7	84.3	83.2	85.0	83.5	85.6	83.9	86.0	84.7	86.8	84.5	84.4
	69.0	61	45.3	80.6	46.4	81.5	47.1	82.2	47.3	83.2	83.3	84.0	83.5	84.3	84.2	85.2	85.6	83.9
	68.5	60	48.3	80.0	44.7	80.7	45.8	80.7	46.3	81.5	46.7	82.2	47.0	82.6	47.7	83.5	83.3	81.9
83	71.5	67	87.1	84.3	87.3	84.3	88.3	88.4	88.8	85.9	89.1	86.4	89.3	86.8	89.7	87.1	90.3	88.0
	70.5	66	84.0	90.8	84.6	91.3	85.3	91.8	85.6	92.4	86.0	93.0	86.1	93.3	86.7	93.8	86.8	89.4
	69.0	63	49.0	42.0	49.3	45.3	50.4	45.8	51.0	47.3	51.4	47.8	51.6	48.1	52.3	48.6	87.0	86.4
	68.0	61	47.4	43.1	48.2	44.0	48.8	44.8	49.4	46.5	49.9	46.1	50.1	46.4	50.7	47.1	85.7	84.0
	67.5	60	45.7	41.3	46.6	42.3	47.2	43.0	47.8	43.7	48.4	44.4	48.8	44.7	49.3	45.5	84.0	82.1
80	71.5	66	89.2	87.8	89.7	88.3	91.0	88.8	91.4	89.1	91.6	89.5	91.8	89.8	92.1	90.1	92.6	94.4
	70.5	65	86.0	94.1	87.5	94.6	87.9	95.2	88.3	95.8	88.6	96.1	88.7	96.3	89.3	96.8	89.5	91.7
	69.5	64	88.6	90.4	84.3	91.0	84.7	91.7	85.2	92.3	85.6	93.0	85.7	93.3	86.2	93.8	86.0	94.1
	68.0	62	50.3	46.7	51.6	47.4	51.8	48.2	53.1	48.7	53.4	49.2	53.6	49.5	53.9	50.1	87.5	86.2
	67.0	60	47.0	43.0	47.8	43.8	48.4	44.6	48.9	46.3	49.4	45.8	49.6	46.1	50.2	46.8	86.0	83.8
78	70.0	66	83.3	86.6	83.7	86.9	84.0	86.2	89.4	87.1	89.6	87.5	89.8	87.8	90.1	88.1	89.0	90.4
	68.5	64	84.0	92.1	86.5	92.6	86.9	93.2	86.2	93.8	86.6	94.1	86.7	94.3	87.3	94.8	89.2	89.3
	67.5	62	51.6	48.4	52.3	49.0	52.7	49.7	53.2	50.3	53.5	50.6	53.7	50.9	54.3	51.5	88.0	86.4
	66.5	60	48.3	44.7	49.0	45.4	49.6	46.2	50.1	46.7	50.5	47.2	50.6	47.5	51.2	48.3	86.5	84.6
	65.5	58	45.0	41.0	46.0	41.8	46.4	42.6	47.0	43.2	47.4	43.8	47.6	44.1	48.2	44.8	85.0	82.7
75	68.3	65	83.5	86.4	88.9	86.9	89.2	87.3	89.5	87.6	89.7	87.9	89.8	88.0	90.1	88.4	89.5	91.1
	67.0	63	85.3	93.8	85.7	93.2	86.0	93.8	86.4	94.1	86.6	94.5	86.8	94.8	87.1	95.1	89.0	89.7
	66.0	61	51.9	48.1	52.5	48.8	52.9	49.5	53.3	50.0	53.6	51.1	53.7	51.3	54.1	51.8	87.5	86.0
	65.0	59	48.6	45.4	49.2	46.0	49.7	46.7	50.2	47.3	50.5	47.8	50.7	48.1	51.2	48.8	86.0	83.7
	64.0	57	45.3	41.7	46.0	42.4	46.6	43.3	47.1	43.7	47.5	44.3	47.6	44.6	48.2	45.1	84.5	81.9
	63.0	55	42.0	38.0	42.8	38.8	43.3	39.7	44.0	40.3	44.4	40.8	44.6	41.2	45.0	41.8	83.0	80.2

Table 1, presented here by permission from York Corporation, may be used to determine when cold air ducts need insulation to prevent condensation on the outside of the ducts.

The left portion of the table applies to straight ducts, that at the right to elbows. The latter classification includes any devices in the ductwork which cause turbulence or impact of air against the duct wall. The values in Table 1 are the lowest dry bulb temperature of the air inside the duct at which condensation will not occur on the outside of the duct for the given ambient air conditions, duct velocity and duct finish.

Example: At what dry bulb temperature of the air in a duct cause sweating if the surrounding air is 85F dry bulb, 70 wet bulb, and 63F dewpoint if the air flows at 1,000 fpm in a black duct.

Solution: Opposite 85F dry bulb in Column 1 and 70F wet bulb in Column 2, find, under 1,000 fpm and black finish, 43.1F dry bulb temperature at which sweating would occur.

For conditions not covered in Table 1, use the following formula:

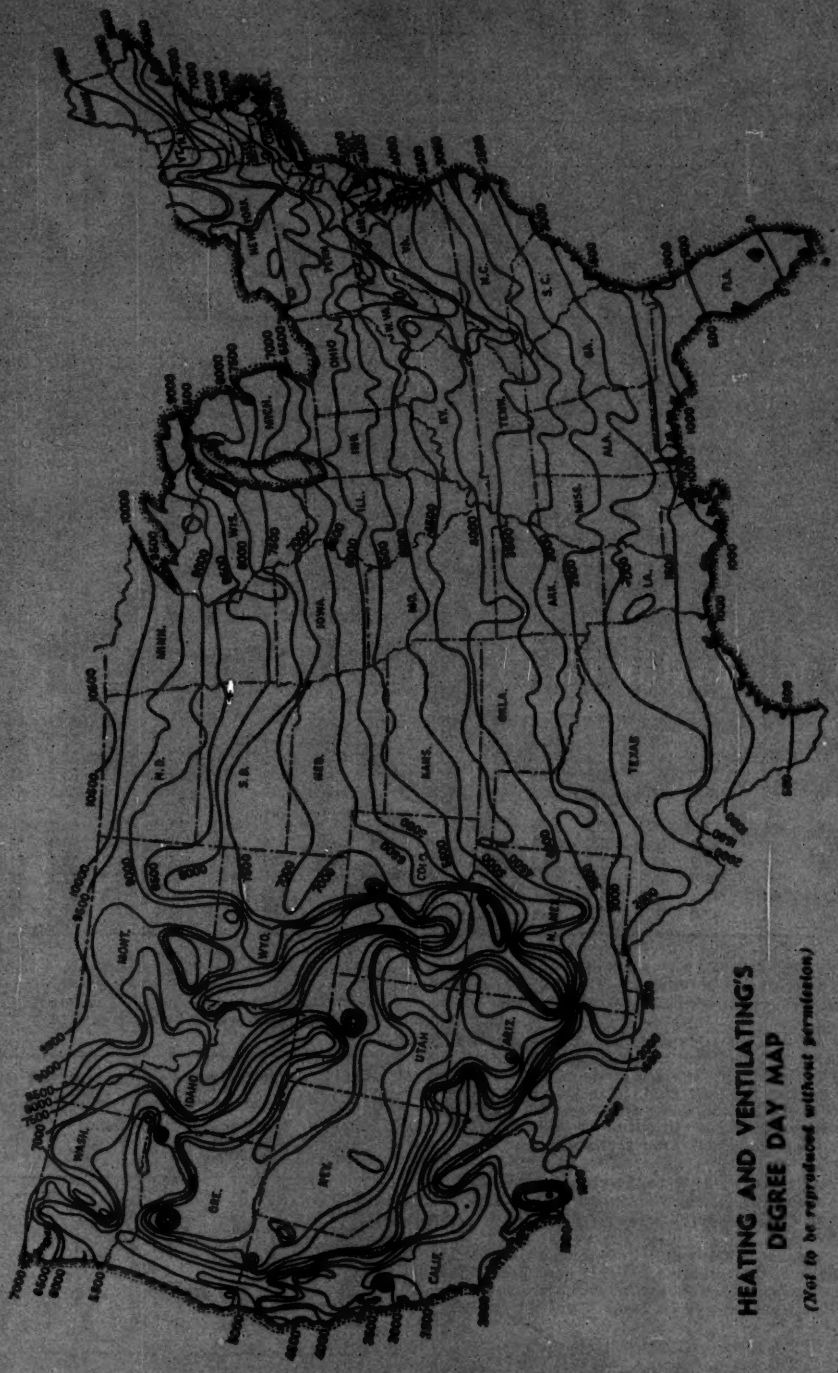
$$t_s = t_r - [S\,(t_r - t_d)]$$

where t_s is the dry bulb temperature of air in the duct, t_r the dry bulb temperature of air surrounding the duct, t_d the dewpoint temperature of the surrounding air, and S the sweating factor given in Table 2.

TABLE 2—SWEATING FACTOR FOR USE IN EQUATION

Velocity, fpm	Straight Duct, Painted or Black Finish	Straight Duct, Bright Finish	Elbow, Painted or Black Finish	Elbow, Bright Finish
500	...	...	1.88	1.85
750	1.86	1.86		
1000	1.81	1.81		
1250	1.77	1.78		
1500	1.74	1.75		
1750	1.71	1.73		
2000	1.69	1.72		
2500	1.66	1.70		

DEGREE DAY MAP OF THE U. S.



installs

CLARAGE HEAVY-DUTY FAN EQUIPMENT

Fine Pharmaceuticals!...the making of over 700 different kinds has started in this great plant of the Upjohn Company, 10 minutes south of Kalamazoo.

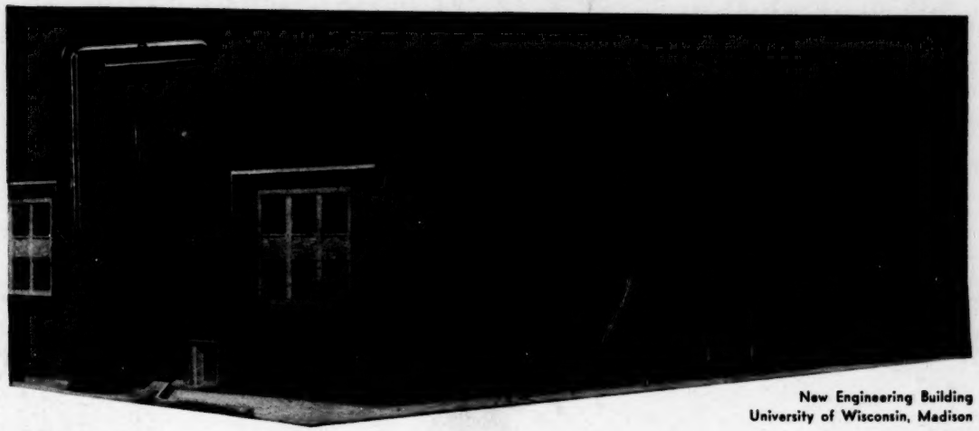
Here much of the manufacturing...***to maintain integrity of product***...is dependent upon air conditioning. 120 complete systems handling 2,800,000 c.f.m. are installed.

A multimillion dollar project... Engineers and Builders, The Austin Company, Cleveland.

Upjohn has had more than a quarter-century of experience with Clarage Equipment. It well may be that this was the deciding factor in selecting Clarage ***HEAVY-DUTY*** Fans for ***every one*** of the air conditioning systems operating in this new Upjohn plant.

CLARAGE
—HEADQUARTERS for Air Handling and Conditioning Equipment

CLARAGE FAN COMPANY
KALAMAZOO, MICHIGAN
APPLICATION ENGINEERING OFFICES.. ..IN ALL PRINCIPAL CITIES



New Engineering Building
University of Wisconsin, Madison

When colleges build

JOHNSON CONTROLLED TEMPERATURE SAVES FUEL DOLLARS

College classroom and laboratory buildings usually are in use from eight o'clock in the morning until five in the afternoon. Much heat is wasted when all rooms are maintained at "occupancy" temperature, at night and over the week-end. That fact was realized in planning the first unit of the new Engineering Building at the University of Wisconsin, to house the Electrical Engineering and Mechanics Departments.

Johnson *Dual* Thermostats, 135 of them (at least one in every room and corridor), control Johnson Valves on 190 convectors. The instruments are designed to maintain proper occupancy temperatures in areas which are in use or reduced economy temperatures in spaces which are vacant. A central time switch resets the *Dual* Thermostats according to the usual program for each day of the week. Merely by pushing a button on the cover of the instrument, the occupant of a room which is occupied at odd hours may restore the temperature in that one space to the normal comfort level.

Johnson Control, in Wisconsin's newest Engineering Building, is applied also to unit ventilators in shops, ventilating systems for interior corridors and air conditioning equipment which serves laboratories where certain conditions must be maintained the year around.

Investigate Johnson *Dual* room-by-room temperature control now. It is equally adaptable to new and existing installations. Whatever the temperature problem may be, call a Johnson engineer from a nearby branch office. There is no obligation. JOHNSON SERVICE COMPANY, Milwaukee 2, Wisconsin. Direct Branch Offices in Principal Cities.

JOHNSON *Automatic Temperature and Air Conditioning* **CONTROL**

DESIGN • MANUFACTURE • INSTALLATION • SINCE 1885